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NEW SOUTH WALES.

DEPARTMENT OF MINES.

N.S.W. GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 7.

MERCURY, OR "QUICKSILVER,"

IN

NEW SOUTH WALES,

WITH

Notes on its Occurrence in other Colonies and Countries.

BY

J. E. CARNE, F.G.S.,

Assistant Government Geologist.

SECOND EDITION.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

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Department of Mines,
Sydney, 21st February, 1913.

Sir,

I have the honor to submit for publication the second edition of No. 7 of the Mineral Resources series, entitled "*Mercury, or Quicksilver, in New South Wales,*" by Mr. J. E. Carne, F.G.S., Assistant Government Geologist.

Considerable interest attaches to the occurrence of mercury ore (cinnabar) n this State, on account of the demand which exists for the fluid metal in connection with the gold-mining industry.

The occurrence of cinnabar, at Cudgegong, near Mudgee, was known as long ago as 1841, and since that date the mineral has been recognised in quite a number of other localities, but, unfortunately, up to the present time it has not been found in a sufficiently concentrated form to enable it to be economically wrought.

In the present compilation Mr. Carne has carefully recorded all the known facts connected with the occurrence of mercury in this State, and has also given much useful information in regard to its occurrence and production elsewhere.

It is thought hat this little work will prove useful to the mining community, and will stimulate prospecting for this very important metal.

I have the honor to be,
Sir,
Your obedient servant,
EDWARD. F. PITTMAN,
Government Geologist.

The Hon. Alfred Edden, M.L.A.,
Minister for Mines.

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INTRODUCTION.

Prior to the practical application of the valuable amalgamating property of mercury in silver metallurgy by a Mexican miner in 1557, the use of the metal, though of ancient date, was restricted chiefly to the very limited demands of the fine arts; the brilliant pigment "vermilion" being prepared from the natural or artificially produced sulphide of mercury.

The Mexican discovery rapidly augmented the demand for quicksilver for the extraction of silver from its ores, and correspondingly increased its output. The extension of amalgamation to gold-mining and milling at a comparatively recent date, however, gave the principal impetus to the industry, and has governed all subsequent demand and supply.

The powerful affinity of mercury or quicksilver for gold, and the ease and efficiency of its application as a collector and saver, render it practically indispensable to the gold-mining industry. Its usefulness and comparative rarity—for mercury occurs in relatively few places in workable quantities—maintain for it continuous demand and value, though the reported control of a powerful combine or "ring" may, and probably does, frequently unduly influence the latter.* Demand and supply, therefore, may not always balance fairly at ruling market rates, which are subject to considerable fluctuation.

The capricious occurrence and comparative poverty of mercury ores, combined with cost and loss in reduction, in the majority of instances narrow the margin of profit to extremely fine lines. Becker, in 1888, estimated the cost of production at 90 per cent. of the average price.†

Hence in this, as in all other metalliferous mining, the lowest grade deposits demand the maximum of knowledge and experience. Rich deposits can sustain experimental or undue working loss, the avoidance of which in treatment of lower grades represents the only possible margin of profit.

It is imperative, therefore, that the possible inception of the mercury industry in Australasia should be safeguarded in this direction. Haphazard methods of management must give way to wiser counsels in the institution of an entirely new and difficult enterprise in these regions.

In the early days of gold discovery in California and Australia, the sudden excessive demands for quicksilver, operating on a slender market, forced values to an abnormal height (over £27 per flask of 76½ lb. being realised, according to Egleston),‡ which decreased gradually in direct ratio with increasing supply and waning gold production until £9 per flask was reached in 1866. In 1870 a sudden rise to £29 per flask took place, according to the same authority; after which it fell steadily to about £5 per flask in 1883, since when it fluctuated between £5 10s. and £9 12s. 6d.§ per flask up to 1900, the rate now ruling being about £8 12s. 6d.

The present average market value appears likely to be maintained unless phenomenal discoveries ensue, for, notwithstanding the rapid advance in metallurgical and electro-metallurgical science, no substitute or process is

* According to "The Mineral Industry" (Vol. xix, 1910, p. 590). the market for quicksilver is controlled by the Rothschilds, of London and Paris, according to Government reports.

† Geol. of Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii, 1888, p. l.

‡ Metallurgy of Silver, Antimony, and Mercury in the United States, 1890; by T. Egleston, vol. ii, p. 799.

§ Mining Journal, 1900, lxx, No. 2366, p. 227.

foreshadowed to completely contest the monopoly of this valuable mobile metal, or dispute its economic utility and efficiency as a gold saver when the precious metal is in a condition open to attack.

Chlorination and cyanidation gold-recovery processes are independent of mercury in their especial spheres; yet these are generally subordinate and subsidiary to ordinary amalgamation.

The cost of chlorination restricts the use of the process, with rare exceptions, such as the oxidized ores of Mount Morgan in Queensland, to treatment of concentrates after amalgamation, in which gold is mechanically cloaked by sulphides of baser metals. Extraordinary fineness and a filmy coating of iron oxide prevented perfect contact with the Mount Morgan gold.

Cyanidation was at first almost equally as rigidly confined to tailings—or exceptional ores—containing gold in so fine a state of division as to render specific gravity inoperative and contact impossible during water transport over amalgam plates, but direct cyanidation is now practised after coarse breaking or crushing of free-gold ores, as at Peak Hill, London Mine, etc., in this State.

According to the "Mineral Industry" (xix, 1910, p. 590):—"The advance of the cyanide process in the treatment of gold and silver ores has caused a decrease in the demand for quicksilver for amalgamation. The substitution of earth pigments for mercury in the manufacture of vermilion has also caused a decrease in the use of the metal, but the products from the cheaper substitute are inferior."

The importance, however, of workable deposits of mercury in a gold-producing country cannot be easily impaired. Unfortunately, Australasia has not yet been able to add it to her list of profitable mineral products, though in New South Wales, Victoria, Queensland, and New Zealand the principal and only workable ore, the sulphide cinnabar and its varieties, has been found in more or less hopeful quantities (associated, in some instances, with the native metal), from which small quantities of mercury have been locally retorted.*

This work must be regarded as a statement of the occurrence of mercury in New South Wales, and the progress of its mining development, supplemented by notes on discoveries in the neighbouring States, and on the principal sources of the World's supply; the object being to stimulate interest and promote research, in the hope of further and more important discoveries within Australasian territories.

* Mr. R. M. Johnston, in the Tasmanian Official Record, 1892, p. 126, mentions the selenite of mercury (*Onofrite*), but the locality is not given. In the same work for 1893, p. 10, the occurrence of mercury with other ores in Silurian rocks is recorded. The locality is, however, again omitted.

MERCURY, OR "QUICKSILVER."

(Physical Properties.*)

A silver-white lustrous metal, fluid at ordinary temperatures. Colour silver-white with slight bluish tinge, and perfect metallic lustre. Solidifies at — 39·38° C. Contracts upon solidification, forming a white, very ductile and malleable mass, which is readily cut with a knife.

Specific gravity, when fluid at 0° C., is 13·59. Specific gravity of solid mercury is 14·19. It crystallizes in forms of the cubical system. Specific heat of solid mercury between — 78° and — 40° C. is 0·0247; that of the fluid metal, between 0° and 100° C. is 0·0333. Its electrical conductivity, according to Matthiesen, at 22·8° C., is 1·63, silver at 0° being taken as 100. Its thermal conductivity according to Calvert and Johnson is 677, compared to that of silver taken as 1,000.

Mercury is volatile to a slight extent at ordinary temperatures. The boiling point of mercury, according to Dulong and Petit, is 360°, according to Regnault, 357·25° C.; it is converted into a colourless vapour, the density of which is given as between 6·7 and 7·03. The rapidity with which mercury volatilises on boiling depends to a great extent upon its purity.

When mercury is impure it does not run in spherical globules, but in pear-shaped ones, and leaves a film on inclined surfaces of paper or glass. When agitated with air, it then leaves a black powder; by violent agitation of mercury with various fluids, as also by rubbing it up with certain bodies such as sugar and grease, it is converted into a fine dark grey powder. Vapours of mercury have a most injurious effect upon the animal system. In all operations in which mercury vapours are evolved, it is therefore necessary to take special precautions to protect persons engaged therein.

Alloys of Mercury.

Mercury amalgamates readily with gold, silver, zinc, tin, cadmium, lead, and bismuth; with copper easily when finely divided, but with difficulty in the massive state; arsenic, antimony, and platinum amalgamate with difficulty; iron, nickel, and cobalt not at all directly.†

Chief Uses.

Amalgamation of gold and silver; preparation of vermilion; in medicine; barometers, thermometers, mirrors, &c.

The great density of mercury, and its regular expansion and contraction by increase or diminution of temperature, render it most suitable for filling barometers and thermometer tubes.

Ores of Mercury.

Cinnabar (HgS)—Mercury Sulphide. Specific gravity, 8·99; hardness, 2 to 2·5; contains 86·2 per cent. of mercury. The most important ore of mercury.

---

* Schnabel and Louis. Handbook of Metallurgy, 1898, ii, p. 250. † *Ibid.*, p. 254.

VARIETIES.

Metacinnabarite.—Black variety, non-crystalline. Lower specific gravity than cinnabar.

Hepatic Cinnabar.—Cinnabar mixed with bituminous matter, which gives it a red to black colour.

A mixture of cinnabar with idrialite (C_3H_2) occurs at Idria.

Coralline Ore.—A mixture of cinnabar, bituminous matters, and about 60 per cent. of calcium phosphate.

Ammiolite.—An earthy powder, colour deep red, regarded as an antimonate of copper mixed with cinnabar.

Composition.—Rivot's analysis of similar mineral from Chili gave :—

Antimony	36·5	per cent.
Mercury	22·2	,,
Telluride	14·8	,,
Copper	12·2	,,
Quartz	2·5	,,

Properties.—Earthy powder, colour deep red.

Occurrence.—Filling cavities in the quartzose or argillo-ferruginous gangue of mercurial tetrahedrite.*

Onofrite.—A sulpho-selenite of mercury occurring at San Onofre, in Mexico.

Tiemannite.—Mercuric selenide.

Coccinite.—Iodide of mercury ; Mexico.

Livingstonite.—A sulphide of antimony containing mercury.

Composition.—

Sulphur	22·1	per cent.
Antimony	53·1	,,
Mercury	24·8	,,
	100·00	

Barcenite.†—Antimonate of Mercury. Huitznes, State of Guerrero, Mexico.

Composition.—Santos gave following analysis :—

Antimony	50·11	per cent.
Sulphur	2·82	,,
Mercury	20·75	,,
Calcium	3·88	,,
Oxygen	17·61	,,
Water	4·73	,,

Properties.—Massive ; structure finely granular. Brittle. Hardness 5 5. Specific gravity 5·343. Lustre dull, colour dark grey, streak ash-grey with slight greenish tint.

Mercurial Fahlore, or *Tetrahedrite*, sometimes contains up to 18 per cent. of mercury (Schnabel and Louis).

Zinc-blende occasionally contains small quantities of mercury.

Calomel, Mercurous chloride, Ag_2Cl_2=Chlorine 15·1, Mercury 84·9=100.

Occurrence.—At Moschellandsberg in the Palatinate, coating the cavities of a ferruginous gangue, associated with cinnabar—crystals often large and well-defined ; also at the quicksilver mines of Idria in Carniola ; Almaden in Spain, etc.‡

Coloradoite.—Composition, Mercuric Telluride—HgTe=Tellurium 38·5, mercury 61·5=100.

Occurs very sparingly in Colorado with quartz, gold, native tellurium, and sylvanite.‡

* C. Y. Wang, Antimony, etc., 1909, p. 35. † C. Y. Wang, Antimony, its chemistry, etc., 1909, p. 36.
‡ Dana.

Principal Quicksilver Deposits and their Geological Distribution.

"Quicksilver has been produced in large quantities in but few localities. The principal productive regions have been Almaden in Spain, Idria in Austria, Kwei-Chan in China, Huancavelica in Peru, and California.*

"The great quicksilver mine of the world is Almaden, which has been worked since at least 415 years before the Christian era, and perhaps still longer. What quantity of ore was extracted from it in ancient times and in the Middle Ages there is no means of knowing, further than that Pliny reports 10,000 lb. of cinnabar a year as brought to Rome from Almaden (Sisapo). The product was certainly never large until the amalgamation process was invented in 1557. Since that time the product has increased pretty steadily, and the output since 1850 is nearly equal to that of the entire eighteenth century. The deposit is said to grow richer in depth, and is certainly far from being exhausted; on the contrary, in the method of exploitation followed, large pillars of ore are left as reserves. The contents of these reserves would be sufficient to yield the usual product for very many years to come, but no authoritative statement of the total amount of metal contained in them has been made. The total recorded yield is nearly four million flasks."†

"The prevailing rocks of the Almaden district are schists, quartzites, and sandstone, together with small quantities of limestone, all of Silurian or Devonian age. . . .

"The chief ore is of course cinnabar, accompanied by relatively small quantities of metallic mercury. Pyrite occurs in small quantities, and Caron detected chalcopyrite. Gangue minerals have been said to be almost wanting, but Nöggerath detected a little heavy spar with the ore, and spots of bituminous matter are sometimes found. I found quartz gangue abundant, both in the reserves and in the newer exposures.

"The deposits of Almaden consist of three tabular masses of ore, nearly 600 feet long, and from 12 to 25 feet in thickness. They stand almost vertically, and nearly coincide in position with the surfaces of stratification. . . . The first of the three consists of a stratum of sandstone (or quartzite, as it is called by some authors), impregnated to a large extent with cinnabar. The impregnation differs in degree, and is sometimes so complete that de Prado infers a partial replacement of the material of the rock by the metallic sulphide. Most later writers have accepted de Prado's view, but I could find no evidence to sustain it. In the two more northerly bodies the deposits consist of quartzite, intersected by stringers and seams of cinnabar. The seams are sometimes parallel to one another and sometimes intersect the rock in every direction. Occasionally, portions of the quartzite appear to be impregnated with cinnabar. The walls of the deposits are formed by quartzite and slate. When quartzite is the wall-rock the ore dies out into it gradually, but scarcely a trace is to be found in the slate. . . .

"The ore does not always follow a single stratum, but, according to Kuss, sometimes passes abruptly from one strata to another.‡

"It is a very remarkable fact that the Almaden mine appears to grow richer as the depth increases. No other known quicksilver deposit exhibits this valuable peculiarity excepting the Idria. It is also interesting to note that the other deposits of the Almaden district have given out in depth, though they occupied a similar position in the same rocks."§

* G. F. Becker, Geology of the Quicksilver Deposits of the Pacific Slope, 1888, p. 4. † *Ibid.* Equal in Spanish pounds to 135,714 tons.—J.E.C. ‡ *Ibid.*, pp. 29 and 30. § *Ibid.*, p. 31.

The Idria mine in Austria-Hungary was discovered during the closing years of the fifteenth century, and has been worked by the Government since 1580, according to Becker,* who described its geological occurrence in the following terms :—

> "The region surrounding Idria is composed of carboniferous, Triassic, and later rocks, which have been subjected to great disturbance.
>
> "The principal fissure on which dislocation took place can be traced on the surface. It is also exposed in the mines, where the crushing and crumbling of the Triassic beds, which it traverses, are plainly visible. The attendant parallel fissures are likewise exposed by the workings. The Triassic strata belong to various subdivisions of the Alpine Trias. (Wergen, Guttenstein, Wengen, and Ikonca groups.) Lithologically they consist of schists, sandstones, and more or less dolomitic limestone. All of these stratigraphical divisions, and all of the lithogical varieties of rock, carry more or less ore in the neighbourhood of the fissures, while none of the rocks carry ore outside of the region of disturbance. Furthermore, the deposits lie along the fissures, having the same strike and dip as these. There is thus abundant evidence that the ore deposition and the fissure system are directly related.
>
> "The form of the deposits differs greatly in various parts of the ore-bearing region: To the south-east the fissures cut across the beds, and the ore forms true and unmistakable veins filled with wall rock, cinnabar, and gangue minerals. In the northern part of the mine the fissure for some distance follows the planes of bedding of the Triassic rocks, and the ore is interposed between the beds somewhat as if a stratum. The cinnabar is found, however, not only between the strata and impregnating strata, but in the cracks penetrating the sedimentary beds, showing that the deposition followed the disturbance, and that the coincidence of the fissure and the planes of bedding are due only to the fact that these, when nearly vertical, were surfaces of least resistance."†

At Nikitowka, in Southern Russia, cinnabar occurs impregnating sandstone of Carboniferous age, having a thickness of 46 feet. The average grade is stated to be 0·6 per cent. These deposits rank next in importance to those of Almaden and Idria, in Europe.

The most important mercury deposits in North America—the New Almaden, New Idria, Napa Consolidated, Etna Consolidated, Altoona, and Great Eastern—occur in California. At one time their output exceeded that of Almaden, in Spain; but, unlike the latter, the deposits decreased in value with depth.

The North American mercury deposits are stated by Schnabel and Louis to occur in a "zone of slates of the cretaceous and tertiary periods, consisting of talcose, micaceous, clay and siliceous slates, serpentines, sandstones, limestones, and dolomites, penetrated by numerous outbursts."

"This zone of slates is more or less strongly impregnated with cinnabar in various places, at some of which, especially where serpentine and sandstone are in contact, the proportion of mercury is a very high one, amounting to as much as 35 per cent. The ore occurs both as contact deposits and also disseminated in serpentine and sandstone. At various places the cinnabar is accompanied by pyrites and bituminous substances; at others it occurs impregnating chalcedony, which may then contain as much as 3 to 10 per cent. of mercury."

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* Geology of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii., 1888, p. 38.
† *Ibid.*, p. 39.

The deposits at Sulphur Bank, in California, and Steamboat Springs, in Nevada, are especially interesting on account of their association with still active geyser action. Cinnabar here accompanies sulphur, which at Sulphur Bank was first mined. The average grade is reported as 1·75 per cent. of mercury.

Le Neve Foster* states that at Steamboat Springs a number of hot springs exist along a series of fissures about one mile in length. Siliceous sinter is being deposited by them. The sinter contains many of the heavy metals, viz., antimony, arsenic, cobalt, copper, gold, iron, lead, manganese, mercury, silver, and zinc.

Of Sulphur Bank the same writer records that the quicksilver is here found in beds of neocomian age as impregnations and irregular seams. The ore is accompanied by quartz, opal, iron pyrites, calcite, bitumen, and marcasite. Hot springs are common in the mine, and many of them give off gases, viz., carbon dioxide, sulphuretted hydrogen, marsh gas, nitrogen, and ammonia.†

Becker states‡ that "rocks inclosing quicksilver deposits are of very diverse ages, ranging all the way from Archæan granites and schists to recent strata and lavas. The lithological variety of the enclosing rocks is equally great, including limestones, sandstones, and shales, many kinds of metamorphic strata, and massive rocks of acid, neutral, and basic types." He further states that quicksilver deposits occur along the great axes of volcanic disturbance of the world; also that cinnabar occurs in "true, simple fissures and veins, in impregnations, and stockworks."§

"The facts recorded point to the supposition that most of the quicksilver deposits, if not all of them, have been formed in a similar manner. They have all been deposited from solution, for the gangue minerals could have been formed in no other way.

"The gangue minerals are few in number and substantially the same in all deposits." . . . They are crystalline silica, opal, calcite, and dolomite."

Cinnabar is being deposited from thermal springs at high temperatures at Pozzuoli, in Italy, Steamboat Springs, Nevada, and Lake Omaphere, New Zealand, and there is reason for believing that similar conditions prevailed in all deposits.

The connection between quicksilver deposits and lines of profound volcanic disturbance is pointed out by Becker, and illustrated by a sketch map of the world. The greater part of the known occurrences of Eurasia (including Pyrenees, Alps, and Himalayas) are distributed along the "Alpimalayan" chain.

The Italian deposits are regarded as along an offshoot from the great belt of disturbance.

The occurrence of Kamschatka and Japan lie along a line of disturbance marked by a series of active and extinct volcanoes. The deposits of the East Indian Islands are associated with similar evidence of dynamic action.

The American deposits from Alaska to Chili lie near the coast along the western ranges of the Cordillera System, and the line on which they occur is marked from one end to the other by manifold evidences of profound disturbance.

Those of New Zealand are also accompanied by evidence of disturbance marked by volcanoes.‖

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* Ore and Stone Mining, 1894, p. 75. † *Ibid.*, p. 74. ‡ *Ibid.*, 452. § Geology of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii, p. 4. ‖ Geol. of the Quicksilvecr deposits of the Pacific Slope, 1888, p. 51.

R. B. Symington, writing of the Californian deposits, states :—

"Generally the veins are mineralizations, along faults occurring near the contact of metamorphic and unaltered rock. A variety of serpentine, locally called 'quicksilver rock' is the usual metamorphic rock; while sandstone and shale constitute the unaltered strata.

"Occasionally the ferruginous shales are interlaminated with bands of jasper which often has a bold outcrop, and, looking like cinnabar, is sometimes mistaken for the latter, but the real veins seldom show a bold outcrop." [Large boulders of red jasper in the Cudgegong cinnabar drift have been similarly mistaken.—J.E.C.]

"When a porous rock like sandstone forms the wall of a vein, it is often impregnated with cinnabar for a considerable distance from the fissure, and the true vein matter may be comparatively barren; but if clay, or any impervious rock, forms the wall, no ore will be found beyond that line.'

The writer recommended cross-cutting in consequence of the above features. He further stated that formerly it was the custom to search only for higher grade ore; now everything over 0·5 per cent., or ½ per cent., is worked. More than once the waste dumps have been turned over with profit.

*Texas.**

The bulk of the mercury obtained in the Terlingua district, Brewster County, Texas, is described as coming from the limestone area (Edward's Limestone); but of late active operations have been confined to the bituminous-shale area, west of Terlingua Creek.†

"The quicksilver ores in the district are in the upper and lower cretaceous. The region is characterized by many intrusions of igneous material, chiefly trachyites and andesites. . . . . The ores are chiefly cinnabar, but some favoured localities, confined almost entirely to the limestones, have yielded much native metal and, in addition, the rare oxychlorides, terlinguaite, montroydite and eglestonite, and one place has yielded the ammonia-bearing material known as Kleinite."

Arizona (Central Western).

The occurrence of mercury in Central Western Arizona is described by H. Bancroft‡ as in "arenaceous shales, presumably of pre-Cambrian age, which have been metamorphosed into quartz-mica schists. . . . . Epidote is present in almost all the schists, and some of them are highly chloritic. Near the veins the wall rocks show calcite and epidote in abundance, with some zoisite."

Tourmaline, gold, silver, copper glance, and siderite is associated with cinnabar in some of the deposits. It is regarded as highly probable, therefore, that the cinnabar has been derived from mercurial tetrahedrite.

Mexico.

"The important Mexican quicksilver deposits were all formed incidental to extensive thermal spring action, resulting from the geologically recent plutonic activity, and occur generally in limestone (except in a Durango locality). The quicksilver is generally accompanied by gypsum, and often by antimonial minerals."§

* W. B. Phillips, Eng. and Mining Journ., Feb. 25th, 1911. † Mineral Industry, xix, 1910, p. 593.
‡ Bull. 430 U.S. Geol. Survey, 1910, p. 152. § The Mineral Industry, xviii, 1909, p. 622.

Peru.

"The enormous deposits of quicksilver ore in the vicinity of Huancavelica, Peru, have been worked intermittently since the year 1571. . . . The Huancavelica cinnabar belt is said to be about 60 km. long, in a north-west and south-east direction, the Santa Barbara mines occupying only a small portion of the entire area. The cinnabar occurs as impregnation deposits in sandstone, limestone, and calcareous conglomerates. With cinnabar and native mercury small deposits of galena, sphalerite, pyrite, arsenio-pyrite, and realgar are associated. The ore from workings which have been exploited averages about 2 per cent. mercury."*

Age of Inclosing Rocks.

G. F. Becker† sums up the conclusions at which he arrived regarding the age of inclosing rocks in the following terms :—

> "From the crystalline schists, presumably of Archæan age, to Quartenary beds, strata of all the larger groups of geological formation are known to carry cinnabar. The mere age of the inclosing rocks cannot, therefore, be a controlling factor in the distribution of mercurial ores. More deposits are found in Pre-Tertiary rocks than in those of Tertiary or Post-Tertiary age, a fact susceptible of very simple explanation. Cinnabar deposits are also found in granite and in eruptive rocks, including Post-Tertiary basalts."
>
> "*Lithological character of inclosing rocks.*—Cinnabar occurs in conglomerates, sandstones, limestones, and shales, or in all the great lithological subdivisions of unaltered strata. It also occurs in quartzites, slates, and serpentines and crystalline schists, as well as in basic and acidic volcanic rocks. Thus the lithological character of the inclosing rock does not determine the deposition of the ore. If there is any rock for which cinnabar seems to exhibit a partiality, it is sandstone ; but rich deposits are common in limestone, shale or slate, and serpentine, and are not unknown in other rocks."†

Grades of Quicksilver Ores Worked.

L. H. Eddy‡ states that :—

> "Most of the ores being worked at present in California or other States are below 0·75 per cent. Those of the New Idria Mine averaged 0·496 per cent. for 1909."

Of the Texas deposits W. B. Phillips§ states :—

> "From a long and intimate acquaintance with the district"—[Terlingua, Brewster County.—J.E.C.]—"I think that no one can depend on large supplies of ore that will average from 1·5 to 2 per cent. of Quicksilver. The operations that were under my charge gave an ore that carried a little over 2 per cent. of metal, and we purposely graded it down to about that quality. There is little ore elsewhere in this country that averages so well."

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* Mineral Industry, pp. 622-623. † Geol. of the Quicksilver Deposits of the Pacific Slope, 1888, pp. 50-51.
‡ The Mineral Industry, 1910, xix, p. 592. § *Ibid.*, p. 595.

The New Idria, California, in 1909 treated 67,247 tons of ore for 8,900 flasks of mercury; equalling 0·496 per cent. The cost of mining and treating a ton of ore was $3·14, and the profit $1·63.*

The Napa Consolidated Quicksilver Company reduced 18,583 tons of ore in 1909 for 1,605 flasks of mercury; equal to 0·32 per cent.†

The New Almadin, in Santa Clara County, treated 0·2 to 0·3 per cent. ore.

The Monte Amiata deposits (Italy) contain 1 per cent. of mineral (60% mercury). The chief mine—the Abbadia San Salvadore—turns out 25,000 tons of 1 per cent. ore yearly.‡

In Mexico, the ore from the San Simon and San Esteban mines in the Bella Union field in Guerrero, contains about 2·1 per cent. of mercury; but on an average that extracted from the other mines of the district carries only 0·2 to 0·5 per cent.§

In Peru, the Huancavelica deposits have yielded so far about 2 per cent. of mercury.

The Auerbach Mining Works in the Bachmut district of Ekaterinoslav, produced 90,000 tons of quicksilver ore in 1910, which yielded 360 tons of quicksilver; equal to 0·4 per cent.‖

Vincente Spirek¶ gave the metallic contents of ores treated in the most important mines in 1897, as:—Almada, 8 per cent.; Idria, 0·8 per cent.; Nikitovka, 1·0 per cent.; Siele, 1·2 per cent.; Carnoechino, 0·6 per cent.; Monebuono, 0·4 per cent.; California, 1 to 3 per cent.

Quicksilver—Ore Dressing.

C. Le Neve Foster,** writing of quicksilver ore dressing, states:—

> "The great intrinsic value of quicksilver ore enables hand picking to be carried further than would be compatible with a mineral of little worth.
>
> "At Idria the loss of mercury was so great under the old system of wet dressing, in spite of the high specific gravity of cinnabar, that this method was given up some 50 years ago. Nowadays, the preparation for the smelting is done solely by crushing, sizing, and hand picking. The stuff broken in the mine is separated under ground into waste—poor ore and rich ore. The first is left in the workings, and the two kinds of ore are tipped separately on to a grating with holes of 4 inches across. The coarse lumps are crushed by Blake's stone breakers, and the broken ore which is too big to pass through holes of $\frac{4}{5}$ inch is hand picked: the portions so separated are made ready for the smelting works by further crushing. When poor ore is being treated, waste can be picked out and thrown away at once. The stuff passing through the $\frac{4}{5}$ inch mesh is crushed by rolls and sent to the smelting works.
>
> "The 'smalls' which pass the 4 inch grating are screened on a 2 inch sieve; the coarse goes to the stone breaker and the fines to screens of different sizes. All that is over $\frac{4}{5}$ inch is picked, and some waste taken out; what is under the size is passed through the rolls, and so made fit for the furnaces."

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* The Mineral Industry, 1909, xviii, p. 617. † *Ibid.*, p. 617. ‡ *Ibid.*, p. 620. § *Ibid.*, p. 621. ‖ *Ibid.*, xix, 1910, p. 595. ¶ The Mineral Industry of 1897, vi, p. 568. ** Text Book of Ore and Stone Mining, 1894, pp. 627 and 628.

R. H. Richards* points out that the chief ore of quicksilver (cinnabar), though of high specific gravity, is so soft, and shines so badly when crushed, that a large loss is incurred whenever wet concentration is attempted, and adds that :—

"With modern furnaces, the cost of extracting quicksilver from its ores without concentration is stated to be no more than the cost of concentration alone. For these reasons, the only treatment given to quicksilver ores in this country† is to crush them in jaw breakers and dry them. They are then ready for the furnace."

"At Idria, Austria, the method of preparing the ore for the furnaces is to crush it dry in rock breakers, and then to subject it to hand-picking and sizing by screens. Average figures show that out of 100 tons of concentrated material there are 41·5 tons of coarse material (over 20 mm.), assaying 0·35 % quicksilver, 54·1 tons of fine material assaying 0·67 % quicksilver, and also 4·4 tons of high grade stuff, assaying 8·4 % quicksilver. During the last year recorded, the undressed ore was raised from 0·67 % quicksilver to an average of 0·85 % by the dressing."

The same authority describes the practice of dressing at Idria :— ‡

"The ore is hand sorted in the mine into two classes (*a*) and (*b*). The (*a*) grade contains a medium amount of mercury and rich ore, and the (*b*) grade is ore from the vein walls containing a large proportion of gangue. Wet crushing was carried on from 1694 to 1842, when the losses were found to be too great, and the treatment here given was introduced, and has been in vogue ever since."

"The (*a*) grade of ore from the mine goes to (1)—

1. Grizzly with 50-millimeter openings. From the mine and (2) delivers oversize to (2) and undersize to (3).
2. Breaker. From (1); delivers, *via* elevator, to (1).
3. Trommel with 5-millimeter holes. From (1); delivers oversize to (4), and undersize, periodically, to (9).
4. Trommell with 10-millimeter holes. From (3); delivers oversize to (5), and undersize to (7).
5. Trommel with 20-millimeter holes. From (4); delivers oversize to (6), and undersize to (7).
6. Picking table. From (5); delivers rich, medium, and poor grades into three different bins in (7).
7. Bin with 5 compartments. From (4), (5), and (6); delivers each grade separately, to (8).
8. Breaker set to 5-millimeters. From (7); delivers to (9).
9. Picking table. From (3) and (8); delivers medium concentrates containing 20 % mercury, and rich concentrates containing 30 % mercury to the continuous furnace.

"The (*b*) grade of ore from the mine goes to (10)—

10. Grizzly with 70-millimeter openings. From the mine and (11) delivers the oversize to (11), and undersize to (12).

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* Ore Dressing, 1903, vol. ii, p. 1074. † United States.—J.E.C. ‡ *Ibid.*, vol. iv, 1919, pp. 1919-1920.

11. Breaker. From (10); delivers, *via* elevator, to (10)

12. Perforated screen with 20-millimeter holes. From (10); delivers oversize to (14), and undersize to (13).

13. Perforated screen with 10-millimeter holes. From (12); delivers oversize to (15), and undersize or sand, between 0 and 10-millimeters, and running 1 % in mercury to the reverberatory furnace.

14. Picking table. From (12); delivers ore, between 20 and 70 millimeters, and running 0·5 % in mercury to a shaft furnace, and waste to the waste dump.

15. Picking table. From (13); delivers ore, between 10 and 20 millimeters, and running 1 % in mercury to the reverberatory furnace, and waste to the waste dump.

Notes on the Metallurgy of Quicksilver.

C. Schnabel* states that two methods are used upon a large scale for the extraction of mercury—"the one depends upon the fact that at a high temperature the oxygen of the air combines with the sulphur of the mercuric sulphide, forming sulphur dioxide, whilst the mercury is set free," according to the following equation:—

(1) $HgS + 2O = Hg + SO_2$.

"The other depends upon heating the mercuric sulphide with lime when the sulphur combines with the calcium, forming calcium sulphide and sulphat e whilst the mercury is liberated:—

(2) $4HgS + CaO = 4Hg + 3CaS + CaSO_4$.

Instead of lime-iron may be employed—

$HgS + Fe = FeS + Hg$.

"In every case the above chemical reactions take place at temperatures higher than the boiling point of mercury; so that the latter is separated in the gaseous form, and has to be condensed."

The first process is effected by heating cinnabar in the air; the second by heating with lime or iron, air being excluded.

The mercury vapours in the first method are diluted with sulphur dioxide, nitrogen, and oxygen, and with the products of combustion if shaft or reverberatory furnaces be used.

In the second method the mercury vapours are in a concentrated condition.

The extraction of mercury by heating in air is regarded by authorities as the most suitable for economic and hygienic reasons. It may be carried out either in shaft, reverberatory, or muffle furnaces. When the two former are used, large quantities of ore can be treated with comparatively small

* Schnabel and Louis. Handbook of Metallurgy, 1898, ii, pp. 260, 261.

consumption of fuel and labour. The process, however, is open to the objection already stated, of contamination of the mercury vapours with other elements, which interfere with condensation and occasion loss.

The extraction of mercury by heating with lime or iron must be performed in retorts. This process, however, requires the ore to be crushed, only small quantities can be treated, retorts last a comparatively short time, costs of fuel and labour are high, and workmen are affected by the fumes when the retorts are emptied out; altogether unsuitable for poor ores on account of cost. The latter can only be treated on a large scale, for which furnaces and continuous roasters are alone adapted, according to Vincente Spirek,* the inventor of one of the most successful improved furnaces.

According to Schnabel and Louis† the losses in the best furnaces and methods have been reduced from 50 to about 6 or 8 per cent. of the amount of mercury in the ore.

Writing on the "Quicksilver Industry of Italy," Vincente Spirek‡ states:—

> "In the metallurgy of quicksilver, one of the first principles is to adapt the furnace to the mine ore, and never attempt to adapt the latter to the furnace by means of wet concentration. It is when poor ores have to be treated that the greatest knowledge and experience in the selection of a proper furnace are required.
>
> "The separation of the ore into grades of varying richness usually takes place in the mine itself, single rich pieces being won by spalling from the ordinary ore. The poorer ores are generally divided by screening into two classes—'coarse ore' of 35 mm. diameter, and 'fine ore,' of less than 35 mm. diameter. The coarse ore is worked either by direct treatment in shaft furnaces by means of coke, coal, lignite, peat, or wood, or in so-called shaft reverberatories by means of gaseous fuel, produced in separate generators. The fine ore, which is sometimes again subdivided into medium, coarse, and fine, is worked in reverberatories (*Fortschauflungsofen*), or continuous roasters (*Schüttofen*). The rich ores are mixed with lime or iron, and treated by sublimation, either in continuous roasters or in muffle furnaces. The actual operations are therefore divided into the roasting method and the sublimation method.
>
> "At the present time nearly all the works employ the roasting method, which consists in decomposing the cinnabar by means of an oxidation of its sulphur through the agency of atmospheric oxygen, and subsequent volatilization of the metallic quicksilver. It is thus evident that the theoretical extraction of the metal is a very simple one. In practical work, however, this is not found to be the case. The greatest practical difficulties encountered lie first in the excessive volatility of the metal, and secondly in its high specific gravity as a fluid, which greatly facilitates its penetration into the ground and into all the foundations, and lastly in a property which has so far received but little attention, and works exactly in an opposite direction to gravity, namely, the sickening of the quicksilver (*Quecksilberschaumbildung*) by fatty substances, which prevent the smallest metallic spheres from coalescing, and hold them as a fine film on the surface of the water, with which they are carried off, thus causing considerable losses."

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* Min. Industry, 1897, vi, p. 569. † Handbook of Metallurgy, 1898, ii, p. 263.
‡ Min. Industry, 1897, vi, p. 569.

As an instance of the leakage or penetration of mercury, Egleston* states that at the New Almaden mine, in California, in 1863, 2,000 flasks (153,000 lbs.) were taken from the ground under and near one of the furnaces, the mercury having penetrated 27 feet to bedrock.†

Cinnabar mining is not in itself harmful, providing native mercury is not present in quantity. The precautionary measures advised against mercury poisoning in mining and smelting are cleanliness, open air, acid foods, and moderation in the use of alcohol.

Treating Low-grade Mercury Ores.

Vincente Spirek ‡ states that :—

"It is absolutely necessary in working low-grade areas to adhere most strictly to all the conditions which may influence the success of the operations. Low grade ores can only be treated on a large scale, for which shaft furnaces and continuous roasters alone are adapted. . .

"The second condition of financial success is the complete utilization of the heat generated. This can be considered as accomplished when the gases escape from the furnace at the maximum temperature consistent with the winning of the metal, and when the residues are discharged from the furnace only after they have given up their heat in preheating the volume of air required by the furnace."§

"As quicksilver becomes fluid at 360 C. it should, therefore, be easily condensible. This, indeed, is the case with gases in which mercury vapor forms the main constituent. It is exactly the opposite in treating poor ores in large quantities, 15 to 30 tons performance per day, wherein dead-roasting thousands of cubic meters of combustion products and steam are produced, in addition to the excess of air used. In this immense quantity of gases the quicksilver vapor is present in very small proportions. Consequently, in order to cool the gases and solid matter, and separate all condensible vapors, a very large and scientifically constructed apparatus is necessary, in which enough time may be given to the mercury to condense and settle.

"The solid constituents of the escaping gases are :—Particles of ore, ashes, and soot from imperfect combustion or formed by the reduction of CO_2 to CO. The most important condensible constituents are :—Quicksilver, water, sulphates, salts of mercury, and sulphuric acid. The gases absorbed by water are :—Sulphurous acid, ammonia, hydrocarbon compounds, etc.

"Many of the solid particles are caught on the sides of the condensing pipes, fall into the collecting tanks, and mix with the mercury, forming the so-called 'stupp.' The stupp in the first collecting tank is so rich that 20 to 30 per cent. of mercury can be collected by the mere process of stirring. The greater part of the metal, however, and in the case of low-grade ores all of it, remains in the stupp, and is recovered by special machines or by a simple rubbing on an inclined service, after being mixed with slaked lime, hot ashes, or clay. Ninety per cent. of the total metallic

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* Metallurgy of Silver, Gold, and Mercury in U.S., ii, p. 814. † A considerable leakage is reported to have taken place in connection with the limited smelting operations at the Ohaeawai Mines, New Zealand, and even in the brief operations at Yulgilbar in New South Wales. ‡ The Mineral Industry, 1898, vi, p. 569. § *Ibid.*, p. 570.

extraction is thus recovered, 10 per cent. remaining in the stupp, which assays 15 to 30 per cent. metal, and is burnt in the small continuous roaster or in the muffle furnace."*

Losses in Quicksilver Metallurgy.

Schnabel and Louis† state that—

"Losses of mercury, which formerly amounted to 50 per cent., and even more at some works, have recently, by a suitable construction of furnace and care in conducting the process, by lining the walls and floors of the condensers and by suitably constructing the latter, and by proper regulation of the gaseous current, been reduced to 8 per cent., and even less of the mercury present in the ores. Considering the small proportion of mercury present in the ores, averaging 1 to 3 per cent., the unavoidable retention of small quantities of mercury in the residues of the latter, the unavoidable formation of soot—[mixture of finely divided mercury, soot, cinnabar, mercuric oxide, mercuric sulphate, other sulphates, quartz, &c.—J.E.C.]—the action of acid waters upon the mercury and the volatility of mercury at ordinary temperatures, the process of the extraction of mercury in its present stage of development must be looked upon as having been very well worked out when the loss is only from 6 to 8 per cent."

The following losses of mercury sustained in different varieties of blast furnaces are recorded by the same authorities:—In the Exceli Furnace at Idria, with ores containing 0·2 to 0·8 per cent. of mercury, a loss of 8·9 per cent. of mercury was sustained.‡

The Langer Furnace (Idria) treating 0·2 to 0·8 per cent. ores, lost 9·12 per cent. of the mercury.§

In the Czermak Furnace (Schüttofen), Idria, the loss amounted to 6·5 per cent. of the mercury in the ores.‖

With reverberatory furnaces—the Alberti Furnace (Idria), treating ore containing 0·4 to 0·6 per cent. of mercury, the loss amounted to 14·8 per cent. of the contained metal.¶

In iron-clad reverberatory furnaces—the first built (by Exeli in 1871), working on ores containing from 3 to 10 per cent. of mercury, lost from 10 to 12 per cent.**

In the Czermak Furnace (altered by Spirek), the loss amounted to 8 to 9 per cent.††

In Shaft furnaces proper—the Valalta Furnace in Venice working 0·45 per cent. ore, the loss is said to have amounted to 22·3 per cent.‡‡

The New Novak Furnace (Idria), treating poor ore, lost 7 to 8 per cent. of mercury.§§

At Littai, in Carniola, in a furnace very similar to the Idrian retort furnace, the loss amounted to 5 to 6 per cent. of mercury.‖‖

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* The Mineral Industry, 1898, vi, pp. 578, 579. † Handbook of Metallurgy, ii, 1898, p. 263.
‡ *Ibid.*, p. 280. § *Ibid.*, p. 289. ‖ *Ibid.*, p. 309. ¶ *Ibid.*, p. 311. ** *Ibid.*, pp. 311, 312.
†† *Ibid*, p. 314. ‡‡ *Ibid.*, pp. 316, 317. §§ *Ibid.*, p. 320. ‖‖ *Ibid.*, p. 326.

At Nikitowka, Russia, ores from the Carboniferous Formation, averaging 0·6 per cent. of mercury, smelted in furnaces similar to the Idrian Czermak furnace, sustain a loss of 12 per cent. of the metal contained.

According to Egleston* the losses of mercury in California are said to amount to 15 to 20 per cent. in the best furnaces. At New Almaden the losses are said to amount to 7·29 per cent., according to some experiments extending over a short period. The expense of further decreasing the loss of mercury is regarded, by the same writer, as greater than the additional value thereby attained

Unhealthiness of Quicksilver Mining.

C. Le Neve Foster quotes Kuss to the effect that—†"Miners suffer from mercurial poisoning unless special precautions are taken. Thus at Almaden, even if the ventilation is good, the miner cannot work more than four to five and a half hours per day, nor can he work more than seven or eight days in a month without injuring his health very rapidly.

"It is true that the miners suffer less than the smelters, which is the reverse of what happens at Broken Hill—[a silver, lead, and zinc mine.—J.E.C.]—and the explanation of this is that mercurial poisoning is mainly due to the vapour of the metal. At Almaden some of the mercury exists in the native state, and is supposed to sublime slowly; but even at Idria, where there is no native mercury, where the ore is less rich than at Almaden and the ventilation excellent, the men only work four hours at a stretch—*i.e.*, four hours in the morning and four in the afternoon, with an interval of rest of four hours.

"The symptoms of mercurial poisoning noticed at Almaden are:—Inflammation of the mouth, salivation and loss of teeth, shiverings, gradual and general wasting away.

"As regards mercurial poisoning, attempts have been made to protect workmen by the employment of suitably arranged fans in front of the condensers, so as to draw off all the gases which formerly escaped from the furnaces and condensers, and by carrying all the gases evolved into stacks, whereby a very marked diminution of mercurial poisoning has been attained. As, however, mercury is volatile even at ordinary temperatures, its vapour rising, according to Brame, up to the height of about 3 feet at 15° C., it will probably never be possible to avoid altogether the inhalation of small quantities of mercury, which are thus conveyed to the blood through the lungs. Mercury vapours produce disturbance of the nervous system, the digestion, the motor functions, and of the lungs, disease of the teeth, poverty of blood, scurvy and scrofula. When breathed in large quantities their effect is fatal. "Among the prophylactic measures that have been recommended against mercurial poisoning are the following:—Cleanliness, open air, acid foods, and moderation in the use of alcohol. Melsens recommends the employment of potassium iodide. This is said to render the insoluble mercurial compounds that have been taken into the system soluble, and cause their separation in the urine. A solution of potassic chlorate is used at New Almaden."‡

* Metallurgy of Silver, Gold, and Mercury, 1890, vol. ii, p. 899. † Text Book of Ore and Stone Mining, 1894, pp. 678-8. ‡ Schnabel and Louis, "Handbook of Metallurgy," 1898, pp. 263, 264.

Locality.	County.	Geological Formation.	Reference.
Bingara, Spring Creek, near	Murchison.. ...	Serpentine and clay slate.	T. W. E. David, Ann. Rept. Dept. Mines N. S. Wales for 1891, p. 234.
Boorook, Clifton Silver Mine... ...	Buller	Claystone	Liversidge, Minerals of N. S. Wales, 1888, p. 52.
Broken Hill, Broken Hill Lode ; Australian Broken Hill Consols Mine.	Yancowinna ...	With silver ores, in schists and hornblendic rocks..	H. Wood, Min. Products, 2nd. Ed., 1887, p. 43.
Carwell Creek, Cudgegong River ...	Roxburgh... ...	Slates, sandstones, and limestones.	W. B. Clarke, Mines and Mineral Statistics N. S. Wales, 1875, p. 201.
Corindi Creek, 5 miles westerly from Woolgoolga, North Coast.	Raleigh (?) ...	In ferruginous quartz ...	Mr. A. McIntosh, Grafton.
Crow Mountain, near Barraba ...	Darling	In quartz Devonian ...	Assay Register, Nos. 98-3127 and 98-3449.
Cudgegong River, 6 miles below Rylstone.	Roxburgh... ...	Devonian sandstones, slates, and limestone.	W. B. Clarke, Mines and Mineral Statistics N. S. Wales, 1875, p. 201 ; W. B. Clarke, The Sydney Magazine of Science and Art, 1857, II, pp. 157-161, 170-173 ; C. S. Wilkinson, Ann. Rept. Dept. Mines, N. S. Wales, for 1884, p. 152.
Dungog, Calton Hill	Durham	(?)	Liversidge, Minerals of N. S. Wales, 1888, p. 52.
Grove Creek, near Trunkey	Georgiana... ...	Alluvial Pleistocene ...	Cat. Sydney Exhibition, 1870, p. 445.
Horseshoe Bend, Clarence River ...	Drake	Felspathic rock	T. W. E. David, Prospecting Board Papers, 91-279.
Mookerawa	Westmoreland ..	(Amalgam)	S. Stutchbury, Votes and Procs., Leg. Council N. S. Wales, 1851, II, pp. 273-9.
Moruya	Dampier	(?)	Liversidge, Minerals, N. S. Wales, 1888, p. 52.
Mudgee (Cudgegong ?)...	Phillip	Sandy schist	W. B. Clarke, Cat. Paris Exhibition, 1855 ; W. B. Clarke, The Sydney Magazine of Science and Art, 1857, II, pp. 157-161, 170-173.
Ophir, near junction of Great Waterhole and Frederick's Valley Creek.	Bathurst	(Amalgam)	S. Stutchbury. Quoted above.
Pretty Gully, 5 miles S.E.	Buller	In quartz vein	Assay No. 02-1,120.
Pulganbar, Gordon Brook, 34 miles N.W. of Grafton.	Drake	In granite and altered sedimentary rocks.	J. E. Carne.
Scone, near	Brisbane	(?)	Mr. Dixon.
Sunny Corner	Roxburgh... ...	(?)	....
Yulgilbar, Clarence River	Drake	Hornblende granite, and diorite.	J. E. Carne, Ann. Rept. Dept. Mines for 1895, pp. 141-144; *ibid.* for 1899, p. 175.
,, Spring Creek, Clarence River	Drake	.....	....

Occurrence of Mercury in New South Wales.

Historical.

The earliest official reference to mercury in New South Wales is contained in a letter from Mr. Stutchbury, Geological Surveyor, to the Colonial Secretary, from Orange, dated 9th June, 1851, in reply to an inquiry as to the presence of mercury in that district. Stutchbury was personally unaware of this, but added: "Report says it has been found near Capertee,"* a neighbouring locality, possibly confounded with Cudgegong, where, on the river of that name, about 5 miles west of Rylstone, it had been discovered, according to the Rev. W. B. Clarke, as early as 1841.†

Under date 18th October, 1851, Mr. Stutchbury announced the presence of amalgamated gold, and the reported discovery of native mercury, in the Orange district, in the following terms :—

> "From indications of the presence of mercury exhibited at a spot near the junction of Frederick's Valley Creek, and the Greater Waterhole of Ophir, also on the Mookerawa Creek, where gold was shown to be in small quantities, externally whitened by an amalgam, and the parties assuring me that they had seen globules of quicksilver in their cradles, and being perfectly aware that native mercury had been found in similar geological positions in Lord Rolles' Estate, High Torrington, North Devon, and near Berwick, in Scotland, and being fully impressed with the great importance of the metal in conjunction with gold-mining, I have diligently sought for it in all likely places. I have some doubt with respect to the first locality, supposing it might have escaped from some amalgamating machine; but at Mookerawa such could not have been the case, for no quicksilver had been used in the creek, and the repetition in precisely the same sort of clay—'decomposed clay slate'—together with its identity with the North Devon case, assures me that native mercury does exists somewhere, and that possibly it may be found in quantity."

Subsequent extensive gold workings in these localities failed to reveal any further evidence of mercury deposits. Professor Liversidge's reference to Mookerawa Creek as a mercury locality is based on the above report.‡

Similar occurrences of globules of native mercury in the shallow gold workings at the "Diamond Mines," about 6 miles easterly from Mittagong, and at Braidwood—observed by the Writer and Mr. J. B. Jaquet—locally regarded as indigenous, are probably also attributable to escape from amalgamating machines.

In 1855, the Rev. W. B. Clarke exhibited "Quicksilver in sand schist from Mudgee."§

The same author, in 1857, in a paper on "Mercury Ores," read before the Philosophical Society of New South Wales, remarked :—

> "In the year 1843–4, I procured from the neighbourhood of Mudgee a small sample of yellow soil, in which were interspersed several minute globules of quicksilver, which is a rare form of mercury in nature; but although the yellow colour agrees very well with a similar substance in which mercury is found in some parts of America, I have never satisfied myself as to the genuineness of the quicksilver. I have sometimes

* Votes and Procs., Lcg. Council, N.S.Wales, 1851, ii, pp. 273–9. † Mines and Mineral Statistics N.S. Wales, 1875, p. 209. ‡ Minerals of New South Wales, 1888, p. 52. § Paris Exhibition, 1855.

thought that it was nothing more than quicksilver spilt by the breakage of a barometer belonging to a previous explorer; for a similar accident happened to myself near Wianbene, on the head of the Shoalhaven, and someone who found the mercury on the ground imagined he had made a discovery.*

A similar discovery was made some years ago on the Orara River road, between Grafton and Nana Creek, so the Writer was informed, caused by breakage in transit of a bottle containing mercury.

The proved occurrence of mercury-ore—cinnabar—about 26 miles east of Mudgee, near Rylstone, lends colour to the authenticity of the find questioned by Mr. Clarke. So far as can be ascertained, native mercury has not been found in association with the cinnabar at the above locality, though both Mr. Wilkinson, the late Government Geologist, and Mr. John Anthes—who worked the deposit for gold—state that some of the drift gold is coated with amalgam. It is well for the prospector and observant explorer to preserve open minds—caution is as necessary in rejecting as in accepting reported discoveries; practical and geological research should confirm or refute.

Further reported discoveries are recorded and commented on by Mr. Clarke in the paper quoted :—

> "When the Hon. E. Deas Thompson was Colonial Secretary, a gentleman produced to him, either in 1850 or 1851, a bottle of quicksilver, which he stated was collected from a waterhole at which he baited his horse, somewhere near Mount Wingen. In 1852 I examined that district, with which I was well acquainted many years before, for the especial purpose of tracing the locality alluded to, and I reported to the Government that I could not find any trace of such a discovery."

Cinnabar (?), reported from Swan Hill, Lower Murray River, prior to the date quoted, was proved by Mr. Clarke and others to be an artificial product, "corrosive sublimate" (mercuric chloride).†

The practical discovery and opening of the Cudgegong cinnabar deposit occurred in 1869. The facts leading up to it were briefly related to the Writer by Mr. S. L. Bensusan, who formed the first company. Having for many years maintained a private laboratory for testing minerals free of cost to prospectors, numerous parcels passed through his hands. In 1869 a sample received from Peter Dickson, of Mudgee, proved to be cinnabar. The sender, however, discredited the determination. An agent of Mr. Bensusan's was therefore despatched to Mudgee, with portion of the original sample, in search of the mineral *in situ*, which he succeeded in ascertaining was located in portion 35, Parish Wells, County Roxburgh. After securing the land by purchase, Mr. Bensusan visited the site, and organised prospecting operations. A rich patch of cinnabar was shortly struck in a shallow shaft (14 feet) in drift. About 5 cwt. of the ore taken from it was subsequently retorted by the late Mr. Charles Watt, afterwards Government Analyst, in a Ure's ordinary gas retort, at Barcom Glen Ice Works, belonging to Messrs. Mort and Nicolle, near Paddington.

Shortly afterwards the Cudgegong Cinnabar Mining Company was formed, with a capital of £30,000 in £1 shares. The sum of £10,000 is reported to have been expended, chiefly in surface work. A bank of three Ure's retorts

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* The Sydney Magazine of Science and Art, 1857, ii, pp. 157-161, 170-173.
† Calomel—mercurous chloride—occurs as a native mineral —J.E.C.

were erected at the mine, with a condensing chamber. In these a considerable amount of cinnabar-bearing drift was treated with lime, but the result was very disappointing, about six flasks of mercury only being produced. A system of concentration, by grinding in a form of arrastra, and washing in ordinary puddling machines, prepared the material for the retorts, the reduction equalling about 10 tons into 1. It appears, however, from a subsequent report by Mr. Bensusan to the Company, that under this system the loss was actually greater than the saving, the sludge carrying away an equal assay value of cinnabar as the reduced material contained. The Company, in consequence, did not long continue operations, and the undertaking was abandoned.

Wet concentration of cinnabar is at all times costly and wasteful. Vincent Spirek states that at Cornacchino Mine, Monte Amiata, Italy, the tailings from wet concentration were worked over in modern furnaces, for a yield of 0·6 to 1 per cent. of mercury.*

Several reports were obtained by the Cudgegong Company on the nature and prospects of the deposit, extracts from which are of interest for comparison with later views.

In a letter by Mr. H. A. Thompson, dated October 12th, 1869, published by the Manager of the Company (Mr. W. H. Deloitte) in the *Sydney Morning Herald* shortly afterwards, it is stated that :—

> "The mine is situated on a flat at the foot of a range in this place bounding the valley of the Cudgegong River. Here several shafts have been sunk through the alluvial deposits filling up the old tributary valley of the main river, only one of these shafts having reached the bedrock of the old valley, at a depth of 102 feet. The alluvium is of the usual character, consisting of beds of clay mixed with sand and rounded quartz. On the joints marking the separation of the different layers the cinnabar is found deposited, in many cases in grains of appreciable size, but for the most part in a state of fine powder. It is also found mixed throughout the deposits of sandy drift, and also in some of the clay beds."
>
> . . . . . .

After alluding to reported rich finds of a misleading character, Mr. Thompson states :—

> "A careful examination of the ground opened has, however, satisfied me that the rich patches of cinnabar there found were of limited extent, and that in taking out the alluvial ground such a large proportion of barren material must inevitably be mixed with the runs of ore as to leave no chance of such an operation being carried on profitably . . . ."
>
> "It must be noted that an alluvial deposit of a hundred feet in thickness has been proved to be mixed with cinnabar throughout, and even close to the surface it is found with a modern deposit of alluvial gold."
>
> "With so friable a material as cinnabar, a much larger proportion would be worn away and carried off by the water than has been left behind."
>
> "It is hardly possible to suppose that the original deposit of cinnabar, whose denudation has supplied such a large amount of ore as indicated above, could be otherwise than of considerable size and richness, and the main object of the company should be to discover the position of the cinnabar vein by tracing up the alluvial deposit to its source."

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* Mineral Industry, 1897, p. 569.

The late Captain Josiah Holman, in a report dated 14th May, 1869, stated that some patches of rich ore had been struck in three shafts on an equal horizon of 40 to 50 feet; the general thickness of the richest bed averaging from 2 to 6 feet in clay formation, through which the cinnabar occurred either disseminated or in patches of higher grade. Above the horizon mentioned the mineral was more sparingly distributed right to the surface.

Carbonaceous shale was reported to have been struck at 91 feet in No. 3 shaft, which was regarded as a favourable indication, though no cinnabar was reported to occur in it.

In a later report by Mr. Bensusan, dated 23rd December, 1869, the interesting clay bed (false bottom of later observers) is mentioned in terms which the latest experience confirms:—

> "About 40 feet from the surface there exists a bed of clay of considerable thickness. I am informed that on the surface of this bed and in the drift above, all the cinnabar hitherto found has been obtained, but beneath it none has been met with."

Several shafts were mentioned in the report, but one only was in use, which had been sunk to bedrock at a depth of 116 feet. At 80 feet a drive was put in towards the hill "passing through the black clay slate" crossing the drive. This no doubt is identical with the "black carbonaceous shale" of Captain Holman's report. Evidently no trace of cinnabar was discovered in the bedrock as the utility of the work was questioned by the writer.

The report dealt exhaustively with the mining and metallurgical plant and the probable causes of the failure which then confronted the Company and shortly afterwards caused it to be wound up.

Reliable estimates of the value of the drift in cinnabar and gold are not possible, but, judging from the results achieved in the past, and the desultory attempts since, mostly for gold, the deposit is certainly not payable. Mr. Wilkinson, at a later date, suggested hydraulic sluicing by pumping water from the river.

Samples of cinnabar from this mine, and from a more recent discovery in the Trunkey district (probably Grove Creek, near the Abercrombie Caves, where a little alluvial cinnabar has been found with gold), were exhibited at the Sydney Exhibition of 1870.*

In 1875 the Rev. W. B. Clarke wrote:—

> "Some years ago I reported on the occurrence of mercury in this Colony, but my expectation of the discovery of a lode of cinnabar has been disappointed. The cinnabar occurs on the Cudgegong in drift lumps and pebbles, and is probably the result of springs, as in California. In New Zealand, and in the neighbourhood of the Clark River, North Queensland, the same ore occurs in a similar way. About 1841 I received the first sample of quicksilver from the neighbourhood of the locality on Carwell Creek, on the Cudgegong, where the cinnabar is found."†

Carwell Creek junctions with the Cudgegong River immediately below the cinnabar deposit. It seems more than probable that Mr. Clarke's previous reference to quicksilver in sandy schist from Mudgee, and his later reference to Carwell Creek, refer to the same discovery.

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* Cat. Sydney Exhibition, 1870, p. 445.
† Mines and Mineral Statistics N.S.W., 1875, p. 201.

In 1884 the late Government Geologist, Mr. C. S. Wilkinson, visited the site, and furnished the following description of the occurrence:—

"Here the course of the river makes a sudden bend from the south-east to the south-west, and across the point formed by this bend occurs a patch, about half a mile long and from 5 to 10 chains wide in places, of a very waterworn coarse pebble drift and red ferruginous sandy clays, with irregular masses of brown ironstone. This drift deposit is the remains of the old bed of the stream, which in the Tertiary period flowed down the Cudgegong Valley, the present river channel having been subsequently eroded. The ranges on either side of the river, which consist of porphyry and Devonian sandstones, shales, and limestones, rise to a height of about 250 feet, and this old drift deposit is seen to have filled the valley to a height of at least 120 feet above the level of the river.—[The barometric elevation of the highest level of the drift was determined to be 75 feet above the river.—J.E.C.] Old shafts and surface excavations show that a considerable amount of work has been done; but as the ground, which is private property, is now idle, I could not ascertain if the prospecting had been carried on systematically. However, Mr. Waters, the manager of a company who had the ground about six years ago, informed me that he sunk a prospecting shaft 203 feet deep, and it was then abandoned. He states that the cinnabar was found, more or less, through the drift, from the surface to a depth of 50 feet on to a false bottom, and that the deposit without cinnabar continued to 117 feet, when the true bedrock of Devonian schists was met with; but at 170 feet, when in black schists, he cut through a vein 4 inches thick, dipping to the south-west, and containing a little cinnabar. He also informed me that this shaft was commenced with the object of striking, at a greater depth than it was sunk to, a ferruginous stratum which crops out on the range about 20 chains to the south, and dips to the north-east; but as this stratum is only soft sandstone, full of fossil shells, I do not think it has any necessary connection with the occurrence of cinnabar.

"Near the deep shaft Mr. Knoblanche pointed out a shaft which he and others had sunk and bottomed at a depth of 68 feet, and he also said that the cinnabar was found above the false bottom, which here occurs about about 40 feet below the surface. The cinnabar taken from here occurs usually in sharp angular pieces, from half an inch in diameter down to the size of fine dust, and pieces have been obtained several pounds in weight."

Mr. Knoblanche informed the Writer that he found one piece weighing 2½ lb., and several ranging from 1 oz. to 10 oz. Mr. Anthes, after several years' experience, has found nothing larger than the pieces presented to the Writer, from 1 oz. to 1½ oz. Mr. Wilkinson's report continues:—

"Often the surface of the cinnabar is somewhat rounded, but this may be the original form, and not due to attrition. I took some of the drift from close to the surface, and on washing it fair prospects of both cinnabar and fine gold were obtained; in these the grains of cinnabar were much waterworn, as might be expected, as the drift at the surface has been much denuded."

"Perhaps the most important feature connected with the occurrence of the ore is that the solid cinnabar is sometimes seen to gradually merge into or impregnate the clay or drift of the deposit in which it is found. This is, then, direct evidence that it has not been drifted by running water, like the water-worn pebbles and other material forming the old

Tertiary lead, and that it has probably been derived from thermal water, which issued from the underlying Devonian rocks and permeated the Tertiary deposit."*

Mr. Wilkinson advised prospecting in the false bottom, to intersect any fissures through which the mineral water came up, which were to be followed down into bedrock. He also advised that the vein said to have been cut at 170 feet should be followed to surface. A good deal of trenching in the Devonian outcrop, higher up the ridge, has been done for this purpose without avail.

Mr. Wilkinson alluded to two adjacent ironstone lodes which he also regarded as of hydrothermal origin, but much older than the mercury springs, and thought it not improbable that cinnabar might be found in them, though he was unable to see any, nor yet in the drift alongside. These deposits have since proved to be very superficial, extending only to a few feet below the surface. A sample of the ironstone recently assayed for mercury in the Departmental Laboratory—No. 4,316—yielded negative results.

Mr. Wilkinson, like Mr. Clarke, favoured a spring origin for the cinnabar, but differed in suggesting a strictly local source for its outflow. The latter, from his allusion to it as "drift lumps and pebbles," evidently regarded the mineral as foreign to the site.

According to Mr. Wilkinson's view, the mercury solutions probably rose from the immediately underlying Devonian strata or bedrock, permeating and impregnating the overburden of waterworn drift and clay. This opinion was induced by the subangular form of part of the cinnabar, the apparent impregnation or merging of the mineral into some portions of the clay and drift, and doubtless to a certain extent also by the reported discovery of a vein in bedrock at 170 feet, carrying traces of cinnabar. The latter, however, lacks confirmation. Several shafts sunk and driven in the bedrock, both before and since the reported discovery, in close proximity, failed to disclose even a trace of the mineral. According to the statement already quoted, in the deep (203 feet) shaft, cinnabar was found more or less all through the drift from the surface to a depth of 50 feet on to a false bottom but not below it, thus far confirming the usual experience. Below the false bottom the Tertiary alluvial deposits are reported to have continued to true bottom at 117 feet, leaving 53 feet of blank bedrock before the small vein was struck at 170 feet.

Mr. John Anthes, who has for the past seven years been working the upper drift for gold, during the latter half of this period sank several shafts into bedrock, and connected them across the trend of the previous workings, but failed entirely in discovering the slightest trace of cinnabar below the false bottom in the drift. In one of the latest shafts, sunk under aid from the Prospecting Vote, a band of very carbonaceous shale was so heavily charged with secondary pyrites that it slacked into a black slimy mud on exposure; tested for mercury it yielded no trace.

The principal rocks encountered were sandstone and slate containing characteristic Devonian marine fossils—*Spirifera disjuncta*, &c. Similar fossils were struck in other shafts.

Several serious difficulties prevent unquestioning acceptance of a strictly local source for the mercury solutions. The proved barrenness of the lower drift beds seem fatal to an ascension theory; whilst the false bottom of clay and the upper impregnated layers of drift indicate cessation of active deposition, and subsequent renewal with later drift material, containing cinnabar liberated by more recent denudation.

* Ann. Rept. Dept. Mines for 1884, p. 152.

If, on the other hand, the false bottom represents an impervious bed above which mercury springs issued from the side of the valley, a reason for so ardy an outbreak without any apparent disturbing influence is hard to find; or why such waters should have failed to follow the sloping contours of the bedrock below the false bottom, which could hardly be expected to effectually prevent the downward descent at this point.

The worn and rounded form of portion of the cinnabar, regarded as possibly original, appears strongly confirmatory of attrition. Angular and subangular fragments adduced as evidence of local precipitation, might, *a fortiori*, be attributed to fracturing of an exceedingly brittle mineral during transport in rough bouldery drift such as that in question.

The inclusion of the angular fragments, chiefly in clay, indicates protection by muddy sediments, as the association of the finer particles with the finest clays points to prolonged suspension. Mr. Anthes confirms the statement that the coarse cinnabar occurs in the pebble-gravel, and the fine in the clay.

The merging into, or impregnation of, portions of the clay by cinnabar, alluded to by Mr. Wilkinson, might also be attributed to slight secondary deposition, a phenomenon noted in connection with the Bingara cinnabar deposits by Professor David,* and at the Yulgilbar mines by the Writer.

Probably the strongest objection to so circumscribed a source for the outflow is the total absence in the wash of the effects produced by the usual siliceous and calcareous accompaniments of mercury solution practically the world over. Chalcedonic or opaline silica and calcium and magnesium salts are characteristic of almost every recorded instance of undoubted thermal deposition of cinnabar, and equally marked are their transforming effects on the enclosing rocks In California an opaline or chalcedonic form of silica is so indicative as to be designated "mercury rock." Becker † states that the "gangue minerals accompanying cinnabar are nearly always silica, often in part of hydrous varieties, or carbonates, in which calcite predominates" (p. 53). "The mineral associations in which cinnabar is found seem to show conclusively that it has been deposited from solutions" (p. 55). The Cudgegong cinnabar-bearing drift is loose and friable, or simply clayey in part. The absence of a calcareous cementing medium is remarkable if mineral springs issued from the Devonian bedrock *in situ*, for limestone is abundant in close proximity to the alluvial deposit. It occurs intercalated in the Devonian series, several outcrops being exposed at short distances south-west, west, and north of the cinnabar mines. In the ferruginous stratum mentioned by Mr. Wilkinson, on the range just above the drifts, ferruginous limestone containing Devonian marine fossils occurs.

Furthermore, it is doubtful whether thermal aqueous action is ever unaccompanied by more or less siliceous solution and redeposition, usually in colloidal form, particularly when, as in this case, siliceous rocks are traversed. Evidence of such phenomena being absent from the drift deposits is, however, supplied by portion of the cinnabar itself, betraying its common origin and association. Several specimens recently presented to the Writer by Mr. Anthes, weighing, as before stated, from 1 oz. to 1½ oz. each, throw clear light on the subject. In these specimens the cinnabar invests and penetrates the usual secondary form of silica. Cavities also occur which may represent one or other of the usually-associated carbonates of lime or magnesia. The specimens, moreover, are clearly water-worn, and may thus be accepted as undoubted evidence of vein or fissure deposition, degradation, and transport.

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* Ann. Rept. Dept. Mines for 1891, p. 239.

† Geology of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii, pp. 53 and 55.

The original spring, or thermal aqueous origin assigned to the cinnabar, is not weakened by these facts, which merely refer to location. The actual site of the outflow is an unsettled question which has been brought into prominence here solely for the purpose of encouraging search beyond the restricted site of much unprofitable labour and expenditure. To this end an impartial statement has been made of the facts and opinions adduced by observers bearing upon the subject, for mere suggestions frequently become accepted facts, solely through time and repetition, and tend to direct research into restricted grooves.

An Adelaide syndicate prospected for the source of the cinnabar at the instigation of Mr. Anthes. A costeen was cut across the spur, about 150 yards, south-westerly from the deep shaft. Above this point no cinnabar was found. Two shafts were also started. One, passing into bedrock at 30 feet from the surface, was abandoned at 44 feet. The second was sunk close to the former, on the dip side, and at 30 feet was still in drift, as might be expected. The only additional fact so far demonstrated in these operations is, that the false bottom of clay, which attains a thickness of 6 or 8 feet in the old workings, is overlapped by the later accumulations. The Devonian beds have been folded into a series of wavy anticlines and synclines, and one of the former striking across the old valley in a north-westerly direction, determined the course of a ridge which has dammed back the deep accumulation of drift which fills the hollow or trough of the corresponding syncline, whilst a shallow sheet of the latest and highest drift passed over the obstruction.

Though cinnabar has not been specially identified with any particular geological period or lithological formation, yet, according to the associations of many notable deposits, those of the Cudgegong Valley immediately surrounding the local deposit appear favourable. In close conjunction are sandstones, conglomerate, shales, limestone, and intrusive porphyry. Search is desirable in and near the limestone, because of the extensive association of this rock with cinnabar, particularly in Mexico; also at and near the junction of the igneous and sedimentary rocks, and particularly up the course of the Cudgegong Valley.

It is noteworthy that the drift, particularly the coarse upper layers, contains red jasper and cherty pebbles and boulders, which are not representative of any of the closely-adjacent rocks. The nearest approach to a similar formation *in situ* is a chalcedonic and ferruginous outcrop at the junction of porphyry, limestone and sandstone on the opposite side of the river, about half a mile from the cinnabar drift. This will shortly receive some attention from Mr. Anthes, who examined it in company with the Writer.

To add to the difficulties of determination, it is confidently asserted by both Mr. Anthes and Mr. Knoblanche that practical trials have failed to discover any trace of cinnabar above or below the present site on the river, though Mr. Clarke recorded Carwell Creek as a cinnabar locality. This stream, as already stated, junctions with the Cudgegong just below the Cinnabar Mine.

In view of subsequent denudation, and redistribution of portion of the cinnabar drift by the medium of the present river channel, it is impossible to accept at least a part of this assertion as conclusive; nor should the failure of previous efforts deter a further and more systematic effort to trace the mineral up stream to its source.

Mr. Warden Snape, referring to the cinnabar deposit, wrote of the "well-known fact that quicksilver ore exists among the Cudgegong mountains,"* but did not substantiate the announcement by any definite instances of locality or occurrence, nor have any since been recorded.

In "Mineral Products of New South Wales," 1st Edition, issued by the Department of Mines in 1882, p. 89, and again in his "Minerals of New South Wales," London, 1888, p. 52, Professor Liversidge quotes "Mines and Mineral Statistics of New South Wales, 1875, p. 201," in reference to the reported occurrence of mercury at Wagonga, on the South Coast, "in a bed some 10 feet thick, about 90 feet above sea-level," which is evidently a mistake, as no mention is made of the fact in the work quoted, nor is anything known of the reported occurrence.

Mercury is also reported in the same work "in the casing of the Clifton Reef, Boorook"; and with cinnabar in a "clay lode, and in the surface grit at Calton Hill, Dungog."

In the 2nd Edition of "Mineral Products," 1887, p. 43, Mr. Harrie Wood, Under Secretary for Mines, records the Barrier Range as another cinnabar locality.

From the Australian Broken Hill Consols Mine, samples of cinnabar have been presented to the Mining Museum by a former manager—Mr. George Smith. In the same institution are specimens of "iodide of mercury," deposited by sublimation on the sides of the vent cracks in the open cut workings in Broken Hill Proprietary, Block 11, since the outbreak of fire in the lower levels of that section. Iodide of copper—marshite—occurs in the Broken Hill lode, and iodine has since been detected in cuprite from the same lode. Possibly mercury occurs in the form of cinnabar in the Broken Hill lode, where iodide of silver also is common, and a new combination of the two volatile metals—mercury and iodine—has been set up by the action of the fire in Block 11, though the natural iodide of mercury may be present as *coccinite*.

The latest discovery of mercury ore in the Colony is described by Mr. A. McIntosh, of Grafton, as occurring on a branch of Corindi Creek, about 5miles westerly from Woolgoolga on the North Coast. Two samples from this locality, consisting of ferruginous quartz with cinnabar, have recently been assayed in the Departmental Laboratory, with the following results:—$\frac{33}{00}$, mercury, 0·26 %; $\frac{28}{00}$, mercury, 0·30 %. Gold and silver traces in each case.

For a number of years cinnabar was found in alluvial gold-workings at Spring Creek, near Bingara. Some fairly coarse worn fragments were presented to the Mining Museum by Mr. Grosbernd, of that town. In 1890 the mineral was discovered in serpentine at the locality mentioned, and shortly afterwards was examined and reported on by T. W. E. David.† The following extracts are from his report:—

"Three distinct geographical formations are represented, as follows:—

"1. Claystones and limestones, possibly of Siluro-Devonian age.

"2. Serpentine, resulting from the alteration of an ultra-basic rock of a decidedly intrusive nature. The lode deposit of cinnabar belongs to this formation.

"3. Alluvials, probably of recent geological age, derived from the breaking up of the claystones, &c., and serpentine, by streams of fresh water and other natural denuding agents.

* Ann. Rept. Dept. Mines for 1882, p. 49. † Ann. Rept. Dept. Mines for 1891, pp. 234–239.

"The claystones and limestones at Spring Creek strike in a N.N.W. direction, and dip E.N.E. at from 60° to 70°. The limestone bed appears to have a thickness of at least 100 feet, probably more, and is evidently stratified with the claystones." . . . . .

"The serpentines at Spring Creek occur in the form of an eruptive dyke mass, from 3 to 5 chains wide, striking either north-westerly or northerly."

"At the time of inspection, lode cinnabar had been found in only two shafts, 40 and 25 feet deep, 15 feet apart. The deposit is described in the report as having no true walls, being, in fact, a dyke of decomposed serpentinous rock, with interstratified layers of soft purple clay shale. The limits of the productive portions of the dyke could only be ascertained by constant testing as the work advanced.

"The cinnabar is disseminated through the mass of the dyke in small spots, from the size of a small pin's head up to that of a pistol bullet. It also occurs in thin films in joints in the dyke. The dyke has so far been proved to be cinnabar-bearing for a length of about 15 feet, with a maximum width of about 3 feet 6 inches, and a depth of 40 feet, this last being the maximum depth attained in the shafts. Although the greater part of the dyke material comprised within these measurements carries traces of cinnabar, the greatest measurements of any portion of it which may be described as being decidedly cinnabar-bearing were represented to us as being about 5 feet high, 4 feet long, and 1½ foot wide." A sample weighing 10 lb., carefully selected by Professor David from the bottom of the 25-foot shaft, was crushed and divided into two parcels, one of which was treated by the dry method, and the other by the wet, with corresponding results, viz.—metallic mercury, 0·01 per cent.

"Summary.—From the occurrence of the cinnabar along the line of contact of an eruptive dyke with a sedimentary rock, it is likely that the dyke will continue to be cinnabar-bearing to a considerable depth, as most contact deposits of this kind show great permanence when followed downwards; unless, however, the dyke stone improves considerably at a depth in its yield of cinnabar, it is improbable that the deposit will prove payable."

Aid from the Prospecting Vote was granted to the best site indicated above, to enable a deeper test to be made (Pros. Papers, 91–1073), but at 78 feet work was abandoned, ostensibly on account of influx of water. Traces of cinnabar were reported to continue to the depth mentioned.

Professor David also visited, in the same year, the site of the first discovery of cinnabar, in the Upper Clarence district, made by Messrs. Kelly Brothers in M.L. 5, Parish Carnham, County Drake, about 3½ miles south-east of Lionsville, and described the occurrence in the following terms:—

"A dyke, 12 feet wide, of felspathic rock allied to serpentine, containing cinnabar, distributed irregularly in spots and minute veins. This dyke has intersected the granite of the district at this locality, and is likely, I think, to be permanent to a considerable depth."

Aid was granted to continue sinking, but was not availed of.

In 1895 a more important discovery was made, about 7 miles north-east of Lionsville, on which the following report was furnished by the Writer :—

REPORT ON A DEPOSIT OF CINNABAR NEAR LIONSVILLE.

Geological Survey Branch, Department of Mines and Agriculture,
Sir, 3 January, 1896.

I have the honor to report that, in accordance with your instructions, I have inspected the recent discovery of cinnabar on Yulgilbar Station, Clarence River.

The deposit occurs about 5 chains from the south-west corner of Portion 15, Parish Ewengar, County Drake, and about three-quarters of a mile west of Clarence River.

The nearest settlement is Lionsville, distant about 7 miles in a south-west direction.

The discovery was made by Laurence Fox about twelve months ago through picking up a loose surface specimen of the matrix containing cinnabar. Actual prospecting began in February last.

A previous discovery was recorded in this district in 1891 at Horseshoe Bend, about 16 miles lower down the course of the river, and about 3½ miles south-east of Lionsville. This site has been surveyed as M.L. 5, of 40 acres, in the parish of Carnham. Mr. Geological Surveyor David reported on this deposit about March of the same year, and recommended aid from the Prospecting Vote for proving it. The occurrence is briefly described as* a dyke, 12 feet wide, of feslpathic rock, allied to serpentine containing cinnabar, distributed irregularly in spots and minute veins. This dyke has intersected the granite of the district at this locality, and is likely, I think, to be permanent to a considerable depth.

The present report will be limited to a brief description of the country rocks, nature and apparent mode of occurrence of the mercury ore, present and suggested future prospecting, &c.

To attempt an estimate of the richness of the deposit, or of the quantity of ore likely to be available at the present initial stage of exploration, would be unfair, even if not altogether impossible. Sufficient data, however, will be adduced to justify the opinion that the prospects are decidedly encouraging, and far superior to those afforded by any previous discovery recorded in the Colony.

Previous Discoveries and Mention.

The localities of previous discoveries with reference to reports thereon may be briefly summarised as follows :—

Locality.	Authority.
Near Rylstone, Cudgegong River, County Roxburgh.	Rev. W. B. Clarke, Min. Statistics N.S.W., 1875, p. 201.
Mookerawa, and Great Waterhole of Ophir, County Westmoreland.	Prof. Liversidge, Min N.S.W., p. 52.
† Clifton Mine, Boorook, County Buller ...	,, ,,
Wagonga, County Dampier	,, ,,
Moruya, County Dampier	,, ,,
Calton Hill, Dungog, County Durham ...	,, ,,
Grove Creek, Abercrombie Mountain, County Georgina.	,, ,,
Near Scone, county Brisbane...	Mr. Dixon.
Spring Creek, near Bingara, County Murchison.	T. W. E. David, Ann. Rept. Dept. Mines N.S. Wales for 1891, p. 234.
‡Crow Mountain District, near Barraba ...	.....
Horseshoe Bend, Clarence River, County Drake.	T. W. E. David Pros. Board Papers, 91-279.

Whilst writing this report a sample of galena and zinc-blende with cinnabar has been brought to the Geological Survey Office for assay, with a statement that it was obtained from Sunny Corner, Mitchell, County Roxburgh.

General Geological Features.

The country at the cinnabar deposit consists of hornblende granite, felsite, and augite-diorite, whilst in the immediate neighbourhood serpentine is largely developed.

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* T. W. E. David, Prospecting Board Papers, 91-279. † These occurrences are evidently based on verbal or non-published reports; hence the references are non-committal.—J.E.C. ‡ Samples from this locality, Nos. 98-3127 and 98-3449, assayed in the Departmental Laboratory, yielded 11·2 and 3·0 per cent. of mercury, the matrix being quartz. No particulars are available of these occurrences.—J.E.C.

The sedimentary rock of the district consists of altered slate, which has been referred to the Devonian formation by the late Government Geologist, Mr. C. S. Wilkinson.* The gold reefs of Lionsville occur in the latter where it has been intruded by granite dykes.

The special feature of the most important mercury mines of the world, viz., association of igneous rocks with sedimentary strata, is absent in the present case. So far as yet proved ore is confined to the igneous rocks.

Prospecting Operations.

At the time of inspection in October last prospecting operations had just been resumed after a short respite. Two shafts have been sunk 20 feet and 50 feet respectively about 3½ chains apart on a line bearing N. 15° E., and S. 15° W. These shafts are on distinct veins, which have an east and west trend (?).

From the 50 feet shaft a line of shallow surface openings has been extended for about 29 chains in a direction 25 degrees north of east. These openings have been made wherever any of the characteristic fine-grained felsitic and chalcedonic matrix appeared at surface. In some instances the openings have been on loose and isolated boulders; in others, however, there is evidence of veins *in situ*, but not sufficiently pronounced to allow of a definite strike being determined for the complete line. It appears more likely that these veins are numerous. Traces of cinnabar were detected in most of these openings, but nothing approaching payable ore.

A second line of shallow openings has been made along a well-defined outcrop of similar rock. This line bears E. 5° S. from a point 80 links south of the 50 feet shaft. The openings extend for about 16 chains east from the shaft; the outcrop, however, can be traced at least twice that distance to the Clarence River, near the west bank of which it forms a bunch or "blow." Some years ago this bunch was prospected for gold. Cinnabar could not be detected here, though numerous freshly broken specimens were examined. I was informed, however, by Mr. T. Bassetti, one of the shareholders of the Cinnabar Mine, that that mineral could be identified upon crushing and washing the samples of the rock.

At the spot marked (C) on plan an opening 7 feet deep has been made in the outcrop referred to, and from that level a small opening or drive has been put in about 4 feet south. At the extreme north and south limits of the opening and drive, hornblende granite is exposed, the intervening rock being felsite, both being much weathered and decomposed. The peculiar feature here represented is the horizontal banding or marking of the rotten felsite by finely divided particles of cinnabar. The decomposed felsite is about 7 feet thick, and carries a small percentage of mercury—about one half per cent.—throughout that thickness. This site is one of the most favourable for prospecting.

Detail of Prospecting and Appearance of Ore in the Workings.

The main 50 feet shaft being timbered for about 20 feet from surface, an examination of the appearance of the ore-veins near the surface could not be made for the purpose of comparison with those presented in the shallow openings above described. Below the timbering the discolouration obscured all traces, if any existed, of the ore to within a few feet of the bottom. In the south-eastern end of the shaft thin veins of cinnabar traverse irregularly about 1 foot of felsite country. In the north-western end a little cinnabar was just beginning to show at the bottom of the shaft.

Specimens of cinnabar were taken out of the upper levels several inches thick; the individual veins, however, at the 50-feet level have narrowed to about 1 inch at thickest. Little importance attaches to this pinching or thinning, because of the capricious occurrence of the cinnabar. Bunches of greater thickness are certain to be met with at intervals where vughs or cavities have been formed in the country.

From the 50-feet level a start has just been made to cross-cut southerly in the direction of the 20-feet shaft. The first shot had broken off a thin skelp from the side of the shaft, which revealed thin veins and a faint impregnation of cinnabar traversing and colouring the felsite country. The actual thickness of the ore body at this point cannot, therefore, be determined until the drive has been extended. A cross-cut in the opposite direction would also, perhaps, reveal an extension of the cinnabar in the country,

At the 20-feet shaft, the cinnabar, quartz, and calcite form the filling of a contact fissure between an intrusion of augite-diorite and the felsite. The cinnabar in the best specimens averages, perhaps, 1 inch in thickness in this vein.

* Ann. Rept. Dept. Mines N.S. Wales for 1889, p. 202.

The appearance of the ore in the small opening marked (*c*) has already been described. In the shallow openings, as has been mentioned, traces only of cinnabar have as yet been exposed.

Probable Mode of Occurrence of the Cinnabar.

As far as the limited amount of prospecting will allow of an opinion being formed, it appears probable that three or more parallel bands of felsite occur, containing veins and impregnations of cinnabar.

The ore-band on the 50-feet shaft is evidently distinct from that in the main line of outcrop, which strikes about 52 feet south of the shaft, because the felsite in that outcrop, as exposed at the opening marked (*c*), is but 7 feet thick, between well-defined hornblende granite walls.

A third band is represented at the 20-feet shaft, and possibly a fourth in the most northern line of openings.

Nature of the Country or Enclosing Rocks.

Characteristic specimens of the country rock were selected and forwarded to the Geological Survey Office for petrographical examination and determination. The following notes upon them have been kindly supplied by the Curator and Mineralogist, Mr. Card, A.R.S.M. :—

"Three types of rocks are comprised—

"(*a*) Fine-grained felsite of a greenish colour, weathering brown when fresh. This is the principal cinnabar-bearing rock, the ore occurring in veins and spots closely associated with quartz and, to a less extent, calcite. These three minerals—cinnabar, quartz, and calcite—are of secondary origin ; they do not occur in fresh, unaltered calcite, but their presence is always correlated with a general alteration of that rock. Pyrites is very generally present, but does not appear to possess any significance with regard to the origin of the cinnabar ore.

"(*b*) A holocrystalline rock-marked 'country.' This consists of quartz, felspar, orthoclase, and much oligoclase (?) hornblende and a little magnetite, may be classed as hornblende-granite. A much altered form of this rock is of great interest, in that the alteration has been accompanied by an introduction of cinnabar, which occurs in small particles within the decomposed felspar, and more abundantly along the divisional planes of the hornblende.

(*c*) "Two specimens of fine-grained augite-diorite from No. 2 shaft."

Mr. Card's opinion as to the secondary nature of the cinnabar and associated minerals in the felsite and hornblende-granite, derived from microscopic examination of selected specimens, is entirely confirmatory of the decision I arrived at in the field.

Though the cinnabar is mainly confined to the felsite bands, yet evidence is not wanting, macroscopic as well as microscopic, of a certain amount of impregnation of the granite itself.

The calcite and quartz occur in veins as well as impregnating the mass of the altered felsite. Small vughs occur which are lined with the crystal faces of the calcite. It is noticeable that when the cinnabar occurs as a vein, no matter how thin, it is entirely associated with the quartz, and separate from the calcite. In no instance in the vein-specimens collected could cinnabar be detected in the calcite. The quartz filling the veins has a translucent appearance, passing almost into clear glassy transparency near the metallic vein minerals. Its outer surfaces form a series of mammillary curves covered with free terminating crystals. On these the calcite has been deposited. Part of the calcite is dark greenish-black ; the colouring matter may be due to chlorite from decomposition of hornblende.*

The felsite in its normal condition is very fine-grained, and greenish in colour, breaking with a cherty conchoidal fracture. Pyrites is fairly abundant in it. Where decomposition has been set up, the texture of the rock has become more closely crystalline in appearance owing to the replacement of portion of the fine felspathic material by crystalline calcite. The extent of the replacement may be judged from the following determination of the lime in an average specimen of the felsite from the bottom of the 50-feet shaft = Lime (CaO) 11·17%, equal to carbonate of lime 20·89 %.

Nature of the Ore.

Associated with the cinnabar is an almost tin-white mineral, weathering bronze, containing copper, antimony, and sulphur. The copper carbonates which occur in small quantity in the upper levels, have resulted from the oxidation of this mineral. The

* Since determined to be owing to inclusions of fine acicular crystals of stibnite.

association of the latter with the cinnabar is too intimate to allow of the perfect separation necessary for adequate test for mercury in it. A complete analysis, however, of the mixed ore has been made by the Analyst to the Department, Mr. J. C. H. Mingaye, F.C.S., with the following results :—

Chemical Composition.

Metallic Mercury	43·68
,, Copper	6·87
,, Antimony	4·44
,, Arsenic	trace
,, Iron...	·55
Alumina	trace
Lime (CaO)	1·26
Magnesia (MgO)	·21
*Gangue	30·46
Sulphur	11·46
Carbonic Acid	·44
Moisture at 100° C.	·25
	99·52

Fine silver, at the rate of 9 oz. 6 dwt. 4 gr. per ton } No tellurium or
Fine gold, a trace (under 2 dwt.) ... ... } selenium detected.

* Chiefly silica.

The copper-bearing mineral penetrates the vein quartz in wedge or cone-shape forms. Mr. Card, who examined all the selected specimens prior to my return, suggests that it may be a mercurial fahlerz; further exploration may furnish sufficiently pure specimens for actual determination.

The first specimen of cinnabar from the Yulgilbar deposit assayed in the Departmental Laboratory yielded :—

Metallic mercury, 60·70%.
Silver, 6 oz. 10 dwt. 15 gr. per ton.
Gold, a trace (under 2 dwt. per ton).

This sample represented the highest grade ore in the principal vein near the surface of the main 50-feet shaft. The following samples were selected by myself from a band of decomposed felsite about 7 feet thick in the small opening at the spot marked (c) on plan.

[4057] "Picked." Decomposed felsitic material forming horizontal pink layers from 1 to 2 inches thick in a vertical section of about 3 ft. 6 in. :—

Metallic mercury, 48%.
Copper, a minute trace.
Neither gold or silver.

[4058] "Average." Decomposed felsitic material, being an average sample selected from the full thickness in the above section :—

Metallic mercury, 50%.
Copper, a minute trace.
Neither gold or silver.

From the pink colour of the horizontal layers a much higher yield would have been anticipated from the "picked" sample than from the average of the whole thickness.

The cinnabar in the soft decomposed felsite must be in a very fine state of division, for its presence is only detected by the faint pinkish tinge imparted to the matrix. Possibly portion of the cinnabar may have been removed during the decomposition and weathering, as a sample of undecomposed felsite, having a pink tinge from included cinnabar, from No. 2 shaft, yielded as follows :—

[4056] "Lump."

Metallic mercury, 1·58 %.
Copper, a minute trace.
Neither gold nor silver.

Hence it is reasonable to expect a higher yield from the undecomposed felsite at a depth at the spot marked (C) on plan.

Origin of the Cinnabar.

Field observation and microscopic examination alike agree as to the deposition of the cinnabar from solution in silicco-calcareous waters which percolated through definite cracks or fissures, and soaked laterally into the country as the corroding solutions attacked its more soluble constituents, and replaced them chiefly from the calcium or lime salts in solution.

It would, however, be premature to offer an opinion as to whether the mercury salts had a deep-seated extraneous source, or were originally leached in minute quantities from the contiguous or underlying granite and redeposited in the way described.

Ore at Grass.

Some of the richest patches of ore have been bagged, but little care has been taken with the bulk of the stone raised from the shafts; hence any estimate of quantity of workable ore—fixing 5 per cent. as the maximum in this case—would be very approximate only. It is certain, however, that a fair proportion of the above grade ore could still be culled from the waste.

Further Prospecting.

The crucial question at the present moment, however, is—what quantity of workable ore is likely to be available in the mine?—a question which requires a practical answer such as systematic prospecting alone can give.

The sites most likely to afford a solution to the query would be the present shafts (A and B) and the site marked (C) on the accompanying plan. The prospecting should be in the direction of deepening the above shafts (including C), driving along the course of the veins, and crosscutting to ascertain the thickness of ore-bearing country.

Conclusion.

I am of opinion, from the mode of occurrence, that the cinnabar is likely to continue to great depths, but whether in sufficiently concentrated form to pay for extraction prospecting alone can prove.

The conditions of occurrence differ from those of the very few paying mercury mines of the world; yet the prospect of developing a paying deposit of moderate extent is decidedly encouraging and certainly superior to any yet obtained in the Colony.

As the existence of a mercury mine in Australia would be of first importance in such a gold-bearing country, I am of opinion that a share of the cost of proving comes well within the scope of the Prospecting Vote. I have, &c.,

JOSEPH E. CARNE, F.G.S.,
Geological Surveyor.

The Government Geologist.

In August, 1899, a second visit of inspection to the Yulgilbar Mine was made by the Writer, and whilst engaged upon the work, the Great Australian Quicksilver-mining Company, Ltd., was formed, to secure and develop the property on more systematic lines than yet adopted.

After the first inspection in 1895, aid was granted to the prospectors—Bassetti and party—to deepen the main shaft, and sink another at a spot indicated. The former was carried down to 95 feet 6 inches, and then temporarily abandoned. The site of the second aided shaft in M.L. 2, was forfeited by the original holders, and shortly afterwards secured by Miller, Pollard, and party, who sank 58 feet 6 inches. Again abandoned, it is now included in the new company's property. At a later date, through the agency of Dr. Flateau and others, two additional shafts were sunk about 26 and 30 feet, and an open excavation made on a later discovery

Several distinct lines of cinnabar-bearing veins, proved by later developments, have been charted on the accompanying plan, and illustrated in section. Distinctive letters on the plan and in the text denote the position and identity of the workings.

The extension of prospecting has demonstrated two facts, viz., (1) a larger amount of cinnabar-bearing rock than formerly visible, and (2) the probable dependence of future operations upon the value or workableness of the lower-grade deposits, which alone offer sufficient promise of quantity commensurate with successful working, for it goes without saying that a minimum yield can only be set off by large, cheap, and rapid output.

Unfortunately the grade of the ore in the latest developments is disappointingly low, bordering so close, if not quite, on the unworkable as to put the contemplated immediate erection of reducing furnaces altogether out of the question at this stage. The first and most pressing necessity is extensive proving on systematic lines, and for this there is both justification and inducement.

It is imperative that the prospective supply and value of the larger deposits should be definitely determined by extending prospecting before a reduction plant is considered.

The brilliant hue of cinnabar—"vermilion"—renders it an intense colouring agent; hence an infinitesimal proportion imparts a very deceptive appearance to a veinstone or impregnated rock. Some of the highest-coloured and most promising-looking portions of the Yulgilbar ore are so lightly charged with this mineral as not to sensibly affect the specific gravity of the matrix. When it is remembered that cinnabar is a heavy mineral, possessing a specific gravity of nearly 9 as compared with 2·6 to 2·7 of the matrix, the disappointing assay results of such samples can be more readily comprehended.

The principal samples selected by the Writer for assay during recent examination were subjected to the specific gravity test in confirmation of the laboratory results obtained. Further microscopic examination of prepared sections of the impregnated veinstone and enclosing rocks reveals at a glance the fineness and paucity of the colouring agent.

Active prospecting had ceased for some little time at the mines, but the Proprietary placed the workings in order, and afforded every assistance during the week devoted to inspection.

It will be seen by the plan that at least four distinct veins have been located, and more or less superficially tested; the most important, probably, being the junction line with the diorite dyke which intrudes the hornblende-granite country. Here the largest defined ore body is exposed, which, from its mode of occurrence, is likely to prove permanent to great depths. An interesting feature is the impregnation of both contact rocks with cinnabar, extending to at least the full width of the shaft (G). From the field and microscopic evidence, it would appear that solfataric mineral solutions, containing mercury and a little antimony sulphides, followed the diorite intrusion along contraction fissures, permeating both dyke and country for a distance as yet unproved.

The diorite dyke is traceable on the surface from shaft G, through M.L. 1, and beyond, and has also been exposed in shaft E, and open cut R, as well as in small openings between G and E.

At E and M exactly similar surface conditions exist as at G. The dyke is very narrow—from 2 to 6 feet wide. Notwithstanding the discrepancy in strike, it is probable that the veinstone at O and P, near the Clarence River, agrees in more than resemblance with the dyke lode noted further west.

Geological Features.—An alteration in the nomenclature of the previously-recorded geological formations has been rendered necessary by extended field research and petrological examination of rocks from lower levels. The deceptive-looking formation previously described as felsite and altered felsite proves to be lode material, a product of the transforming effects of the investing mineral solutions.

Becker states that "the rocks adjoining ore deposits have in many cases been greatly modified. Metamorphic rocks often appear to have been converted into or replaced by more or less dolomitic carbonates by the action of solutions."*

* Geol. of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii, p. 392.

The following additional notes on the petrology of the field, by Mr. G. W. Card, A.R.S.M., are the results of later study of fresh specimens collected by the Writer :—

"[2068.] *Country Rock.*—Medium-grained crystalline, of a prevailing green tint, due to the presence of hornblende. Quartz, hornblende, orthoclase, and plagioclase are conspicuous in hand specimens.

"Under the microscope the felspars are seen to be zoned, and intergrowths of the two varieties are common. Nests of micro-pegmatite are present. The rocks may be most conveniently designated hornblende-granite (granitite of some authors).

"[2056.] Influenced by proximity to the vein. Felspar is clouded beyond recognition ; hornblende has been completely altered ; iron ores and cinnabar are disseminated through the mass, which is also traversed by calcite veins. In places it shows an approximation to a graphic structure.

"[3612.] From G shaft, showing a junction between the veinstuff and country rock. Both are cinnabar-bearing, and the line of contact is marked by the presence of antimonite.

"Under the microscope the cinnabar—along with the metallic ores—is seen scattered through the clouded felspar and vestigial hornblende. The junction with the veinstuff is marked by a narrow band of the latter, consisting of crystalline quartz with some calcite, enclosing blotches of cinnabar. This rapidly verges into a crypto-crystalline siliceous mass containing some calcite, throughout which cinnabar dust is scattered.

"[3621.] G shaft. From the dyke traversing the field. A compact pyritous green rock, with lighter mottling, due to a greenish-white felspar.

"Under the microscope it is seen to consist of plagioclase (perhaps an andesite variety), residual hornblende, chlorite, some quartz, calcite and iron ore. It is doubtful how far the quartz is primary.

"[3611.] From E shaft.—Under the microscope this has the appearance of being a portion of the dyke, highly weathered and mineralised. It is very fine-grained, and carries cinnabar.

"A variation in colour suggested the possibility of a junction between different classes of rocks being represented, but the appearance is due to different degrees of weathering.

"[2064.] From E shaft.—Two specimens taken from the tip at different times. A very compact pyritous green rock, with a specific gravity of 2·87 ; glancing hornblende and lath-shaped felspar can be detected with a lens.

"Under the microscope it is seen to consist of lath-shaped and much altered plagioclase with some orthoclase, prismatic green hornblende, abundant pale green chlorite and granular, practically colourless, epidote, calcite and quartz. The latter mineral increases in abundance with the epidote, and is associated with it, sometimes showing crystal faces.

"It is possible that the epidote and quartz together may represent the larger felspars (probably lime-bearing) of [3621]. There is a slight tendency to an ophitic relationship between the chlorite and the felspar laths.

"The most suitable classification of this rock presents a difficulty. For general purposes it will, perhaps, be best to designate it a fine-grained quartz diorite. Scientifically, its somewhat peculiar constitution and structure, together with its fineness of grain, would bring it near the lamprophyres or aphanites.

"Note.—Although the chlorite might represent augite, that mineral is not certainly present, and the granular mineral, I am satisfied, is epidote. The designation, 'augite-diorite,' applied by me on a former occasion to a specimen from E shaft cannot, therefore, be retained.

"[3622.] *The veinstuff*, from F shaft.—This consists essentially of impure calcite. Through this the cinnabar is scattered in small blotches, minute rods, and dust. It is associated with an equally finely-disseminated metallic ore—magnetite to some extent. The ore is traversed by thin strings of pyrites.

"Several other specimens were also examined. The siliceous veinstuff is very compact, presenting, both megascopically and microscopically, a close resemblance to felsite. The earlier specimens were so regarded, but an examination of an extended series points to a purely secondary origin for the whole."

Further Development.

The main shaft (D on plan) has been deepened from 50 feet, recorded in the first report, to 95 feet 6 inches, and a level has been extended 11 feet easterly at 36 feet from surface. Close timbering obscures any inspection above the level; below it the shaft is inclined about 25° from the vertical, following the underlay of the vein southerly.

The face of the level shows a slight impregnation of cinnabar in the foot-wall. Evidence of fissuring is afforded by a vugh of considerable size, lined with chalcedonic silica.

Below the close timbering to the bottom of the shaft, a distance of about 59 feet 6 inches, the veinstone averages from 4 to 7 inches in thickness, and is well defined at the lowest level. Slight impregnation of the country occurs in places, but the quantity of cinnabar is inappreciable. In the vein the cinnabar occurs as occasional streaks from $\frac{1}{2}$ to 1 inch thick; sometimes two parallel streaks occur about 1 inch apart. The productive portions of the vein-stuff range from 1 to 3 inches in width, but are not continuous; in fact, all trace of cinnabar occasionally disappears for some distance. An idea of the irregular occurrence of the mineral in the matrix, both vertically and horizontally, is gained from its appearance in the shaft and drive. The ratio of cinnabar-bearing to barren matrix equals about 1 in 4 vertically.

A considerable amount of the full width of the vein exposed in the ends of the shaft at 93 feet was gadded out and brought to surface, where the best—or coloured—portion was picked out, broken small, and carefully sampled in the usual way, by mixing and parting. In the Departmental Laboratory large assays, in duplicate, of this material yielded [No. 3373] at the rate of 1·09 per cent. of mercury. An average sample of the balance of the vein-stone extracted, similarly treated, yielded [No. 3372] no mercury. The specific gravity of large pieces of these samples ranged from 2·69 to 2·71.

From the nature of the veinstone, and the capricious occurrence of the cinnabar, it is apparent that a large amount of vein material—apart from the country extracted for the proper dimensions of the shaft or level—would have to be mined in proportion to the workable ore obtained by spalling and picking. Calculated on a specific gravity of 2·7, a cubic foot of veinstone would weigh about 168 lb., or 13 cubic feet, to the ton. Accepting, on the evidence of the shaft, the proportion of workable ore as 1 to 4, 52 cubic feet of veinstone would have to be mined to yield 1 ton of 1 per cent. ore.

As richer streaks of ore were found nearer the surface, allowance must be made for more favourable developments than at present visible. Possibly an additional per cent. could be safely allowed, bringing the average grade of the picked stone up to 2 per cent.

The ore recently experimented on in Sydney before the Directors and others of the newly formed Mining Company, was picked from the material raised during the sinking of the main (95 feet) and a neighbouring shaft.

Though this vein is not in itself workable on account of the thinness and discontinuity of the ore-bearing streaks, it must be taken into account in estimating the possibilities of the whole properties.

From the bottom of the main shaft strike levels are required, and a cross-cut to the dyke-lode, to intersect any intervening parallel veins that may exist. The dyke-lode would be cut from this level about 100 feet below its outcrop.

About 120 feet from the main shaft on the western strike, a more recent shaft (C) was sunk to about 30 feet. Time did not permit of it being unwatered. Judging by the tip, however, the vein in the granite is very narrow, and the impregnation of the country slight.

About 8 chains still further west, apparently on the same line, a small opening reveals the usual chalcedonic veinstone containing a little stibnite (stella), pyrites, and cinnabar.

About 12½ chains E. 18° 20′ N. from the main shaft is another recent shaft (F), locally known as "Doctor's" shaft, sunk 26 feet on the most northern vein, represented by shallow openings at the first time of inspection. The strike of this vein taken in the shaft is N. 55° E., with a slight south-easterly dip.

The shaft is closely timbered to within a few feet of the bottom. Removal of timbering at 14 feet revealed the same thickness of veinstone as at 26 feet, viz., 12 to 14 inches, but more compact. At the lower level the vein is split in two by about 6 inches of country. On either side of the veinstone the latter is slightly impregnated with cinnabar.

Though the barren material and the immediate walls are referred to as "country," the whole is so impregnated with secondary calcite and silica from percolating solutions as to be more correctly described as barren lodestuff.

From the strongest part of the vein at the point of test—from surface to about 10 feet—some highly-coloured veinstone has been extracted in sinking, the hues ranging from bright pink to purple. As conflicting views were entertained of the value of samples of this grade on view in Sydney prior to the recent inspection, tests were made in the Departmental Laboratory under Mr. J. C. H. Mingaye, F.I.C., F.C.S., of typical specimens of the highly-coloured and non-coloured veinstone, with the following results :—

No. 2285—Coloured ... Yield 0·92 per cent. of mercury.
,, 2286—Non-coloured ,, 0·10 ,, ,,

A further sample obtained by chipping the coloured blocks at surface yielded [No. 3365] 0·825 per cent. of mercury.

From the ends and bottom of the shaft at 26 feet, 200 lb. (weighed) of ore were obtained by gadding out the full width of the exposed veins. This was broken small and carefully sampled in the usual way ; an assay [No. 3363] of the test portion yielded less than 0·01 per cent. of mercury.

After selection of the average sample, 24 lb., of the remainder was weighed and reduced to one quarter, by rejecting everything destitute of cinnabar stains. An average of the reduced sample [No. 3364] still gave a return of less than 0·01 per cent. of mercury.

The specific gravity of the "purple" ore, determined from a large piece, equalled 2·85 ; that of the "pink," 2·77.

A picked sample from the principal cinnabar make in the vein at 26 feet, about 2 inches thick, yielded [No. 3368] mercury at the rate of 1·065 per cent.

The shaft at the present level is in poor average veinstone, though a very small proportion might be picked to about 1 per cent. It is apparent, from the superficial test made, that certain parts of the veinstone contain about 1 per cent. of mercury, but the proportion of the latter to the bulk of the veinstone cannot be estimated without further development.

The second deepest shaft (G on plan), locally known as Miller and Pollard's, was sunk at the site indicated by the Writer as (C) in the first report, on the junction line of granite and diorite. The felsite previously mentioned has since been more definitely determined as an alteration product of the investing mineral solutions.

At the surface, evidence of a certain amount of leaching and redeposition was visible in the decomposed outcrop, which was horizontally banded with white and pink, representing alternate solution and impregnation at the various stages of weathering and decomposition. Similar conditions occur at the open cut (B on plan).

As previously recorded, samples [Nos. 4057 and 4058] from the outcrop yielded from 0·48 to 0·5 per cent. of mercury, whilst a sample of the less decomposed rock [No. 4056] yielded 1·58 per cent. of mercury.

The present shaft was sunk 58 feet 6 inches a few feet south of the previous opening, cutting the lode material at some depth from the surface. At 46 feet, to which depth the water was lowered, the full width in the shaft is occupied by cinnabar-bearing lodestuff. The diorite in the centre of the exposed face is about 2 feet thick, and contains finely disseminated cinnabar throughout. On either side decomposed, or highly altered lodestuff, passes gradually into hornblendic granite, cinnabar impregnating it so far as the limits of the shaft permit inspection. A sample taken from the full width exposed at 46 feet yielded [No. 3375] 0·15 per cent. of mercury. Evidently the grade at this level is not equal to the lodestuff previously passed through, as the following assays show. Judging by the material in the shaft tip, which is indiscriminately mixed, sorting will be possible and satisfactory. A large sample of a fine-grained greenish rock (diorite?), crumbling on exposure, yielded [No. 3369] 0·67 per cent. of mercury. A similar test of a pinkish felsitic rock, from the junction of the granite, weathering brown on exposure, yielded [No. 3370] 0·805 per cent. A sample of the coarse-grained granite from the junction [No. 3371] yielded 0·570 per cent.

Along the junction of the granite and diorite, which is well defined, chalcedonic quartz occurs, with nests of stellate crystals of stibnite on its surfaces.

On dissolving a little black calcite from the main shaft (D), a mass of fine acicular crystals of stibnite remained. It is possible that mercury is associated with it, forming the mineral "Livingstonite," though no tests have yet been made.

The diorite dyke, as before stated, can be traced to the west right through M.L. 1, and it is possible, notwithstanding the apparent discrepancy in the strikes, that the veinstone at O and P, near the Clarence River, agrees in more than resemblance with the dyke line.

Between G and E several shallow openings reveal a common class of material, though in places more chalcedonic. At M, a sample of decomposed impregnated rock, exposed at surface, yielded [No. 3374] 0·06 per cent. of mercury.

Shaft E, the 20-feet shaft of the first report, has fallen in; hence no fresh developments are to be recorded here. Still further west, at R, the dyke has been exposed at an excavation; traces of cinnabar only are visible at this point.

B represents an entirely new discovery, where an open cut exposes a width of about 17 feet of rotten hornblende granite, lightly impregnated with cinnabar. The conditions of occurrence at this point indicate a certain amount of progressive leaching and redeposition of the cinnabar, in the horizontal, curving, and vertical seams determined by the shell-like weathering of the rock and the angles of the joint planes. It is noticeable that the principal deposition of the cinnabar is in these lines of soakage, though not confined to them, as the mineral occurs in the rotten granite in the form of fine circular or semi-circular plates or stains exhibiting strong indications of secondary origin. It appears certain, however, that, as in shaft G, the granite will be found in depth to be impregnated with cinnabar from the original deposition.

The siliceous rock exposed in the cutting, which possesses the usual chalcedonic characteristics, probably represents the original line of fissuring and subsequent infiltration of heated mineralised waters from which percolation and impregnation of the enclosing granite ensued.

A test shaft and cross-cut are needed at this site to determine the width and strike of this ore body, which at present are not definable. Until the unweathered rock is reached it would be hazardous to attempt an estimate of the value of this deposit. The extent of the surface impregnation is indicated by the result of a properly averaged sample of about $1\frac{1}{2}$ ton of the material freshly extracted from the full width of the open cut, viz. [No. 3366], mercury 0·035 per cent. An average sample of the seams and joint fillings in the exposed face of the open cut yielded [No. 3367] mercury, 0·115 per cent.

Summary.

It will be seen by the aforegoing statement that whilst the quantity of cinnabar-bearing material in sight has been increased by further prospecting, the grade has not correspondingly improved. The line G to F will probably yield a workable quantity of ore, yielding from 0·5 to 1 per cent. of mercury. From the main shaft (D) and Doctor's shaft (F) lesser quantities of similar grade will be obtainable. From B no ore approaching this grade is yet obtainable; whatever its prospects in depth, it cannot yet be taken into account. The question confronting the newly-formed Company now is: Can ore of the above grade be profitably worked under local conditions? Certainly, even lower grades are successfully operated on in Europe and Russia; but circumstances alter cases, and it is more than doubtful if the Yulgilbar deposits could be attacked on a commercial scale as they now appear. On the other hand, there is every reasonable inducement, as there is every need, for an adequate test to effectually decide their workableness or otherwise.

A little fine cinnabar occurs with gold in the bed of Sandy Creek, on the west side of Clarence River, close to the Yulgilbar Crossing. A slight amount of prospecting has been done in endeavouring to locate the matrix from which it is derived, and traces are reported in a rock somewhat similar to the vein rock at the main mines.

Yulgilbar.—The Great Australian Quicksilver Mining Company (Limited), which was formed to work the Yulgilbar cinnabar deposits at the time the first edition of this work was going to press, unfortunately disregarded the advice tendered as to the imperative necessity of extended prospecting before the question of a reduction plant was considered. A retorting plant was at once entered on, and further prospecting entirely ignored. So far as can be learned of operations during the brief retorting campaign which followed the formation of the Company, all that was done was a drive 50 feet east from the 100-feet level on the narrow rich vein (at D on plan), and a similar distance from the 50-feet level in the same direction, and stoping

from the latter to surface. From this meagre development came all the ore that was treated for a return of about 10 cwt. of quicksilver. So far as the Company's operations are concerned, the question of further proof of the extent of the larger, but lower grade, deposits is still unsolved.

According to the departmental reports in 1902,* Dr. Elliott, in conjunction with Mr. A. Milne, carried out a series of experiments with small parcels of ore which proved satisfactory. One ton of ore treated yielded 2 per cent. of mercury. An improved furnace on the Excelsior Monitor principle, capable of treating 40 or 50 tons of ore per week, was being erected under the supervision of Mr. Milne.

Active retorting operations were begun in 1903; 40 tons of ore were treated for a return of 1,010 lb. of quicksilver.† This practically concluded the Company's mining and smelting campaign.

Pulganbar.—Portions 42, 117, and 132, Parish Pulganbar, County Drake, on the western side of Pulganbar Creek, Gordon Brook Pastoral Holding; about 34 miles north-west of Grafton, and 12 miles from navigable water at Copmanhurst, on the Clarence River.

Copper ore has long been known in this locality—the neighbouring Glamorgan Mine, under the name of "Jakoombi," as early as 1873. The Pulganbar mines were originally started as copper-mines solely. It is locally reported that cinnabar was first discovered by A. McLean. From 1908 to 1911 cinnabar-bearing ores have been received for assay in the Departmental Laboratory, many of them being of high grade. The following assay returns illustrate the nature of the ores received and their respective values:—

Assay No.	Description.	Mercury.	Copper.	Gold.	Silver.
		per cent.	per cent.	per ton.	per ton.
08-1299	Cinnabar	66·25	.....	....	.....
					oz.dwt.gr.
08-2136	Quartz and tourmaline rock, with ochreous material	1·02	.....	trace	1 9 9
08-3341	Quartz with cinnabar; depth, 7 feet; Portion 42..	30·03	.....	,,	trace
09-3057	Quartz with cinnabar; Portion 117; depth, 15 feet	30·42	.....	,,	,,
09-3058	Tourmaline-bearing copper carbonate ore; Portion 42	.....	2·85	,,	oz.dwt.gr. 0 4 8
10-924	Pyritous quartz; Portion 42	.....	4·02	,,	1 17 0
10-925	Quartz with cinnabar; Portion 132	20·48	.....	,,	trace
11-245	Quartz with ochreous cinnabar; Portion 117; depth, 30 feet	1·97	.....	....	.....
11-464	Ferruginous cellular quartz; No. 3 shaft; Portion 117; depth, 30 feet	0·56	.....	trace	oz.dwt.gr. 1 1 19
11-605	Pyritous quartz with cinnabar; No. 3 shaft; Portion 132	33·25	.....	,,	0 10 21
11-606	Pyritous greenish quartz with fahlore	0·74	1·73	,,	1 1 19
11-790	Ferruginous quartz with cinnabar; Portion 117 ..	3·99	.....	,,	trace
					oz.dwt.gr.
11-791	,, ,, ,, ,, ..	5·35	.....	,,	0 10 17
11-1029	Mercurial fahlore; Federal shaft (No. 3); Portion 132; depth, 3 to 86 feet	3·74	9·05	,,	2 14 10
11-1030	Black pyritous quartz; No. 2 shaft; Portion 132; depth, 4 to 90 feet	0·19	2·78	,,	0 15 6

From the Cu Co Mine, formerly known as Flintoff's, on the opposite side of Pulganbar Creek, the only indication of cinnabar yet detected was in the following sample:—[10-1201] Red clay yielding 0·16 per cent. of mercury.

In 1908 the Pulganbar Mineral Prospecting Company, N.L., was formed for the purpose of acquiring and developing the areas held by the Pulganbar Syndicate, Federal Syndicate, and the New England Prospecting Company, N.L., embracing about 400 acres.

* Ann. Rept. Dept. Mines, 1902, p. 57. † *Ibid.*, 1903, p. 55.

The locality was visited by the Writer on the 26th August, 1911, or four days after the inauguration of quicksilver retorting at the mines.

The disposition of the principal workings, and the location of the retort, are shown on the accompanying plan.

The geological formations consist of altered sedimentary rocks of, as yet, unascertained age, intruded by grano-diorite and tourmaline granite.

The principal lode is in the grano-diorite (Federal shaft), and the principal copper lode (No. 1 shaft) in tourmaline granite.

These rocks have been petrologically examined by G. W. Card, A.R.S.M., Curator and Mineralogist, who kindly furnished the following descriptions :—

Grano-diorite :—Federal shaft, Pulganbar ; grey green, weathering lighter ; uneven fracture ; quartz in a dull green matrix ; hornblende and biotite distinguishable here and there.

Under the microscope there is very little biotite, and but little hornblende—a pale altered variety ; some magnetite is associated with the ferro-magnesian minerals.

Plagioclase felspar predominates over orthoclase, and is a variety at least as basic as andesine ; one or two grains of sphene were noticed.

Only one specimen showed the above characters well ; alteration had commenced in all, and in several was very far advanced.

Tourmaline-granite, No. 1 shaft, portion 42.—The dark colour of the greater portion of the specimen is due to the great development of tourmaline.

No. 1 shaft, portion 42, has been sunk in a siliceous copper lode, 4 feet wide, striking north-east, and dipping north-west, at about 60 degrees. An inspection of the levels was not possible, as operations at this site had ceased for some time. The mine manager, Mr. D. H. Thomas, however, stated the depth to be 140 feet. At 80 feet, a level has been driven 60 feet to south-west, and 34 feet in a similar direction at 140 feet. The shaft is timbered into two compartments.

Judged by the material raised during sinking and driving, the ore, which is very siliceous, contains about 3 or 4 per cent. of copper in the form of yellow sulphide.

Near by, and in other parts of the property, are massive outcrops of iron oxide, one close by being sunk on for a reported depth of 60 feet. These may be useful as flux if the silica contents are low.

The copper ore in the above lode is of itself far too siliceous for smelting without concentration, or use of very basic flux.

No mercury ore is discernible in association.

No. 2 shaft in Portion 117 has been sunk in a siliceous copper and mercury lode, containing much iron oxide, so far as open to inspection. Operations being carried on in the oxidized zone at 40 feet. The shaft is reported as 60 feet in depth, but has been sollared over at 40 feet. The lode is estimated as about 3 feet wide, striking N. 20° E., and dipping N. 70° W. at 60°. At the 40-feet level it had been driven on for about 40 feet to the south-west at the date of inspection. The lodestuff is locally estimated to yield 2 per cent. of mercury.

No. 3 shaft, Portion 132.—Not open to inspection. From surface heap the ore consists of irony lodestuff with a little sulphide of antimony, and cinnabar. A sample of the former was tested for mercury, but revealed none.

Nos. 4 and 5 shafts are on the same lode, near the west boundary of Portion 42, it having a thickness of about 2 feet. No. 4 is reported to be 100 feet deep, and No. 5, 20 feet. Neither, however, were opened to inspection.

The lodestuff carries copper pyrites, and resembles that in the Federal shaft. Some rich cinnabar ore was obtained in No. 5, but being in a valley, considerable water was met with. Some lodestuff was estimated to yield 10 per cent. of mercury.

The principal developments at the time of inspection were in the Federal shaft in portion 132. At this site the original discovery of rich slugs of cinnabar was made in the surface soil along and below the eastern outcrop for a distance of 200 feet.

The Federal lode strikes N. 70° E. in grano-diorite, and dips N. 20° W., at 75° down to 53 feet, then at 65° to 147 feet, the lowest level then attained. The ore channel at this depth was 3 inches thick at north-east end of shaft, and 18 inches at the south-west, with very little cinnabar showing. The hanging wall is well defined. The ore consists of copper and iron pyrites, cinnabar, and calcite, in hard quartzoze rock. Specular iron and copper carbonates occurred in the oxidized zone. Very rich cinnabar occurred in two lenses, having a width of 2 to 8 inches.

The first lense of good ore is reported by Mr. Thomas to have had a width of 9 inches at 40 feet, 18 inches at 70 feet, and a similar thickness at 105 feet in the second lens. Between the lenses and below 105 feet the lode is very poor.

Retorting Plant.—The retort constructed for treatment of the Pulganbar mercury ore was designed by Manager Mr. W. H. Thomas, well known as a copper smelter. It consists of a rotating cast-iron vessel of 1 ton capacity, fired from beneath. Rotation is secured by hand-power worm gearing at back end.

The charge consists of 1 ton of ore crushed to $\frac{3}{4}$ inch gauge, and 10 per cent. of lime.

It is estimated that a charge can be retorted, and the retort allowed to cool, and the residues discharged, in twenty-four hours. The residues from the rich picked ores are estimated to contain 14 to 18 per cent. of copper.

A few charges of the rich "slug ore" from the surface at the Federal lode were run through, and two bottles of quicksilver obtained, when the end of the retort cracked.

The alternate heating and cooling necessary, unless very gradual, are always likely to fracture a cast retort of this nature. The difficulty of rotating by hand, when the iron expands on heating, is moreover a drawback. The plant, however, must be regarded as a purely experimental one. The rich ore treated at the start, containing about 50 per cent. of mercury, is no criterion of what can be achieved with the average ore, yielding probably 1 to 2 per cent., or less. The method adopted will probably prove too slow when a large bulk has to be treated for a low yield; a furnace of the continuous-feed type would be more suitable.

The hand-dressing and picking, indicated under the head of concentration, will also have to be carefully considered in local practice, if success is to be achieved, even with the classes of ore already developed.

Pretty Gully, 5 miles south-east, Parish Jenny Lind, County Buller.—Cinnabar in a quartz vein, 1 foot thick, was discovered in 1902 by Selby Tucker. A sample submitted to the Department for assay.

No. 1,120–02 yielded 2·06 per cent. of mercury.

Corindi Creek.—Parish Woolgoolga, County Fitzroy, about $3\frac{1}{2}$ miles W.N.W. from Woolgoolga.—The presence of cinnabar was first noted in this locality by Mr. W. T. Pullin, about 1894, whilst prospecting for gold; the

actual site being Bark-hut Creek, about 1½ mile above its junction with Corindi Creek. The cinnabar here occurs very sparingly, distributed in a quartz vein striking N. 15° W., which was sunk upon for a few feet when first discovered.

On a spur between Bark-hut Creek and a small branch creek, close to which Pullin's find is located, another small make of cinnabar occurs at surface in rubble and clay. From a few inches in width—2 or 3—a trail of fine mineral is obtained by panning.

About 40 chains distant a prospector named Macintosh, in 1908, made a further discovery of cinnabar whilst searching for gold on the north side of Bark-hut Creek.

In 1910 T. Russell and W. Riddell obtained aid from the Prospecting Vote to sink at this site, on the recommendation of Inspector James. This gave rise to a report that the discovery of cinnabar in this locality was entirely new. In 1908, however, a sample of quartz with a little cinnabar was forwarded by Mr. A. S. McKittrick, of South Grafton, to the Department for assay [No. 08–550] which yielded 0·5 per cent. of mercury and traces of gold and silver.

During 1910 the following additional samples were tested in the Departmental Laboratory :—

No. 10–2787.—Broken up sample of quartz and slate ; yield—mercury, 0·22 per cent. ; gold and silver, traces.

No. 10–2792.—Quartz, with traces of cinnabar ; yield—mercury, 0·08 per cent. ; gold and silver, traces.

No. 10–3805.—Quartz and rubble ; yield—mercury, 0·26 per cent.

No. 10–4059.—Quartz and rubble ; yield—mercury, 0·72 per cent. ; gold, 3 dwt. 6 grs. ; silver, 3 dwt. 6 grs. per ton.

No. 4060.—Quartz and rubble ; yield—mercury, 0·30 per cent. ; gold, 10 dwt. 21 grs. ; silver, 2 dwt. 4 grs. per ton.

T. Russell and W. Riddell received aid to sink 25 feet on a narrow quartz vein, striking north and south, the thickness not exceeding 2 inches, very faint traces of cinnabar only being visible in the vein and soft clayey rubble of the decomposing slate country.

Other parallel veins of similar character occur close by on the east, at the site of Macintosh's gold prospecting operations, but the indications of workable cinnabar are entirely unfavourable. [Examined by the Writer in August, 1911.]

New Zealand.

The Ohaeawai cinnabar deposits in the Bay of Islands County, about 30 miles from the old township of Russell and 18 from Kawakawa, are the most important yet discovered in New Zealand. Though known as early as 1870, no attempt was made to work them until 1895, when an English syndicate began prospecting operations, under the supervision of Mr. André P. Griffiths, from whose paper on the subject the following notes are extracted* :—

> "The Hot Springs, better known as Tuwhakino and Ngawha, around which the various quicksilver deposits are clustered, lie about 2 miles to the south-east of Omapere Lake. . . . .
>
> "The face of the district, which at one time must have been the source of intense volcanic action and disturbance, is studded with old craters and extinct volcanoes. . . . .

* The Ohaeawai Quicksilver Deposits ; by André P. Griffiths. Trans. New Zealand Inst. Mining Engineers, Second Session, 1898, ii, pp. 48–58.

"The country around the Hot Springs consists of a series of low undulating, fern-clad hills. To the north-east and south-west these hills are mainly composed of fine blue limestones and firestones, which are covered by layers of varying thicknesses of 'green sand,' marly clays, and flints. All these rocks compose nearly the whole of the Tertiary Coal Measures of the island. . . . .

"These undulating hills form several crateriform hollows of varying diameters and depths, in which are found the Hot Springs and quicksilver deposits. . . . .

"The springs give off large quantities of sulphuretted hydrogen gas and occasionally a little steam. . . . .

"The deposits which have been formed by these springs consist essentially of beds of moderately hard brown and grey sandstones, or solidified siliceous mud, with layers of calcareous and siliceous sinter, through which the cinnabar has been deposited, together with native sulphur. They include also several layers of bituminous shale, containing an appreciable quantity of petroleum oil.

"There are, moreover, deposits of pyrites, with or without cinnabar, in some cases containing traces of gold and silver." . . . .

"The cinnabar occurs principally as lining small cavities and cracks in the solidified muds and green sand immediately surrounding the original fissures of the underlying basalt. Cinnabar is also found impregnating a fragmentary sinter, overlying the very fine muds or sandstone, but below the bituminous shale."

Mr. Griffiths records only one instance of the association of cinnabar and pyrites. Free mercury occurs only in very small quantities, apparently originating from decomposition of cinnabar.

The recent origin of the deposits is demonstrated by the evidences of active formation now in progress. Fine films of cinnabar are being deposited with native sulphur around the small orifices, at the bottom of trenches made during the prospecting operations, by the hot gases and solutions evolved from below; also from the presence of cinnabar in Kauri gum and in the charred trunk of a partially embedded tree.

The richest deposits are described as being nearest to the hottest gas vents; hence, at a very shallow depth a temperature was reached sufficient to preclude mining operations. A bore-hole put down 104 feet ejected mud to a height of 60 feet, followed by boiling water with H_2S in solution.

In their origin and mode of formation these deposits resemble those of the Pacific Slope, California, and of Steamboat Springs in Nevada.

Mr. Griffiths adds that the "cinnabar of Ohaeawai is associated with calcite, chalcedonic quartz, marcassite, sulphur, and bituminous matter.

"It would seem that there is no doubt that, in the case of the Ohaeawai deposits, the cinnabar was precipitated from hot ascending solutions or vapours near the surface. The gases which escape from these springs are mostly sulphuretted hydrogen, steam, and carbonic dioxide, with, possibly, a little carburetted hydrogen."

The following New Zealand mercury localities are also noted in the paper quoted:—Tokomairiro and Russell (native mercury); cinnabar at Puhipuhi, Kerikeri, and the Bay of Islands generally in the North Island. At Waipori, in the province of Otago, in the South Island, quicksilver is found as cinnabar, mostly in the shape of rolled fragments of pure sulphide.

Small quantities of cinnabar as a pulverulent deposit lining the inside of cracks and small cavities of quartz, along the outcrop of the Big Tin Lode at Te Aroah, also on footwall side of lode.

Cinnabar also occurs near the head of the Kaueranga River, in the Thames district.

A further discovery is reported in the *Australian Mining Standard* of the 23rd November, 1899, in the Waitahuna Ranges, 12 miles from Berwick, and halfway between that place and Waipori. Drift cinnabar was traced to a lode 16 inches wide, in which about 3 inches of cinnabar occurs on the hanging wall.

THE TUWAKINO CINNABAR MINES (OHAEAWAI), NEW ZEALAND, SITUATED ABOUT 20 MILES FROM THE BAY OF ISLANDS, AND 12 FROM KAWA KAWA; COMPILED FROM NOTES FURNISHED BY MR. S. L. BENSUSAN, O'CONNELL-STREET, SYDNEY.

"The Tuwakino mercury deposits occur in a freehold of 465 acres, lying to the north-west of the site of the English syndicate's operations at Ohaeawai.

"The cinnabar is brought from below by thermal action, and deposited within the crater of a moribund volcano, in the last stage of solfataric activity. The watershed formed by the margin of the crater concentrates the rainfall and surface drainage into a pool at the bottom, about 60 feet in diameter. This water penetrating to considerable depths becomes greatly heated, and thus affords a ready means of diffusion of the increased temperature to the surface. For some distance round the margin of the pool similar sodden heated conditions exist. Hitherto all attempts to mine round the pool beyond a depth of 10 or 15 feet were baffled by the sodden ground and heated water, and fumes of sulphuretted hydrogen, sulphurous and carbonic acid gases.

"All round the pool for a considerable distance cinnabar is obtainable in every spadeful of earth. The problem, therefore, is how to overcome the difficulties enumerated, which have arrested operations in the past. After two visits to the locality a solution presented itself to the writer in a system of drainage, which the natural configuration of the country renders feasible. By draining the crater of its subterraneously heated water, the cause of the abnormal heating of the surface would be removed, and workable depths could be reached in direct proportion to the level of the drainage. Starting from the crater an irregular line of fissure extends for a considerable distance in a south-easterly direction, and at intervals along this line cinnabar has been met with, but no defined run of it.

"A few years ago, in company with my son, Mr. E. Bensusan, A.R.S.M., an examination and superficial test was made of the deposit. Both cinnabar and native mercury were obtained in several shallow holes round the pool, heat and fumes preventing more adequate testing.

"A second visit with another son—Mr. A. J. Bensusan, A.R.S.M.—was more successful, and suggested the solution already mentioned. By means of a small creek, which affords a natural outlet for the surplus water of the pool, we succeeded in lowering the standard level from 2½ to 3 feet. After allowing the drainage to continue for a few days, a hole was sunk a few feet

from the pool to a depth which could not have been reached without the drainage effected. Here splendid prospects of cinnabar were obtained, from massive lumps to pulverulent material.

"Continuing sinking, at a moderate depth the ground became softer and hotter, and water oozed in ; further operations had, therefore, to be abandoned."

"The result of this superficial test indicates the possibility of turning this valuable deposit to account. By means of a trench round the sides of the crater above the pool, all surface drainage could be diverted to the overflow channel or creek, whilst a pump of moderate power could lower the accumulated water in the pool, and thus allow the surrounding cinnabar-bearing ground to drain and cool.

"The deposit was visited some years ago by Mr. Peake, A.R.S.M., who obtained a quantity of the cinnabar ore and conveyed it to London, where, subsequently, Mr. Snelus, of the Royal School of Mines, assayed it for a return of 55 per cent. mercury.

"As regards the relative richness of this deposit, compared with the known cinnabar mines of the world, which, with the exception of Almaden and New Almaden, average less than 1 per cent. of mercury, all the assay returns of properly-taken samples from Tuwakino, so far as obtainable under the circumstances, ranged from $\frac{1}{4}$ to 6 per cent.

"One of the principal items of expenditure, particularly in connection with high-temperature cinnabar mines like the one in question, is securing and maintaining powerful ventilating machinery, an item capable of considerable reduction at Tuwakino by utilisation of a waterfall of about 200 feet within the property itself. This fall is believed to be sufficient for generating all power requisite for developing the property, ventilation, electric lighting, &c.

"On the south-east of this property, following the line of fissure referred to, a plant was erected to treat the cinnabar found on that ground, but success does not appear to have attended the work undertaken. I do not think that the plant erected was adapted for the work. Furnaces taking charges of 1 cwt. are out of date ; the most economical now used take 50-ton charges, or 1,000 times this quantity. The expense, too, is about a fifth or a sixth.

"The cost of treatment, recorded as 16s. per ton, is out of all reason. In my paper on the mode of occurrence and metallurgy of quicksilver, published in the *Town and Country Journal*, January, 1870, it is shown that in Germany they treat at a profit an ore yielding $\frac{1}{8}$ per cent.—value 6s.

"Some years since Messrs. Cox and Seaver reported on this property, and referring to a report of Mr. J. A. Phillips on a quicksilver mine in South America worked under similar conditions as to heat and moisture, stated that in one of the mines there they work levels 104, 157, 210, 260, and 310 feet from surface ; that the heat of freshly-cut rock was often too great to be borne by the naked hand, but by a complete system of ventilation the mine was able to be worked successfully.

"As far as the cinnabar deposits at Ohaeawai are concerned, certainly those round the White Lake, I can see no reason why they may not be worked from open quarry, using modern, up-to-date furnaces, of 50 tons capacity, when the shifting of the stuff and furnacing would pay with as small a yield

as in Germany, or an eighth of a per cent. Probably it would pay to import German workmen, who know their business, and give them an interest in the results."

New Zealand.—The New Zealand Cinnabar Limited Mine is situated at Karangahake. In the *Australian Mining Standard* of 13th July, 1910, it was announced that "operations have been carried on in the mine for the past two years, and the quicksilver produced has been supplied to several gold-mines in New Zealand with gratifying results. A quantity was also supplied to the Government. Some rich ore was sent to England for treatment. The company has a complete plant at this mine, including a Novak furnace of the latest type, as well as a complete condensing plant."

"*Ascot Cinnabar Mine.*—This mine is situated on the east side of Mackytown, on the Rahu-road, about 1 mile north of the Talisman Mine. The property consists of 176 acres, a mill site of 5 acres, and timber reserve of 20 acres, together with aerial tram and dam site. The cinnabar deposit outcrops on the face of a steep escarpment about 800 feet above the Rahu-road. Here there is a very strong body of very flinty rock, above which is a layer of from 4 feet to 8 feet of andesite. The cinnabar occurs in well-defined, almost horizontal, veins, striking east and west along the contact of the flint rock and andesite, also penetrating the latter, and as kernels and veins in the former. Its full extent has not yet been determined, but it has been traced for a distance of 15 chains. The situation of the deposit enables it to be opened up with comparative ease by removing the overburden and dumping over the edge of the cliff. Some 5 chains in length has been dealt with in this manner, proving the cinnabar formation to vary from 6 inches to 10 feet in width. It carries an average of about 10 per cent. of cinnabar, but there are some rich pockets containing almost pure cinnabar assaying some 70 to 80 per cent. mercury. A drive has been put in at right angles to the face of the cliff, and follows the cinnabar for a distance of 30 feet, when it pinches out. At about 15 feet a soft formation, 18 inches in width, was passed through, carrying pug rich in cinnabar and also nodules of pure cinnabar, the whole averaging about 25 per cent. of mercury. A drive running parallel to the face of the cliff was carried along on this soft formation, good ore being obtained from it. The rich pug is going underfoot in the drive, and appears to be contained in a series of pipes. These are doubtless connected with the source of the deposit. About 10 chains west of the main working, and on the same line, the cinnabar is found again outcropping. A cut put in at this point exposed rich cinnabar, assaying 70 per cent. of mercury. No further work has been done at this point, so that its extent is not yet known. Although comparatively little work has been done, and that chiefly of a prospecting character, there are some 50 tons of ore stacked at the mine awaiting treatment, which averages about 15 per cent. of mercury. Development work has not proceeded far enough to enable any useful estimate of ore in sight to be made, but it is certain that a few hundred tons of ore, averaging about 10 per cent., can be obtained without much deadwork.

"The Novak furnace, installed for the treatment of the ore, is of the latest type, it being double-walled, 21 feet in height by 8 feet diameter externally. The inner wall is of firebrick and the outer of ordinary brick, the whole being surrounded by an iron jacket, which serves to prevent the escape of fumes. The ore and fuel (charcoal) are charged at intervals at the top of the furnace, which is covered by a "bell" with water-seated lid, which enables the charging to be effected without escape of vapour. The spent ore is drawn off through openings at the bottom of the furnace.

"The mercurial vapours are drawn from the furnaces into the condensers, consisting of a series of Y-shaped stoneware pipes, 12 inches in diameter, of which there are three sets side by side. The liquid mercury collects in water-filled troughs running under the condensers. From the condensers the fumes are led into two large chambers containing water-sprays, where dust and residual mercury are collected in the form known as "soot," which is subsequently retreated. The fumes are further conveyed through 150 feet of 12-inch pipes laid under ground, with cesspits every 10 feet for retention of any mercury which may have passed the condensers and chambers.

"An 11 in. suction fan, with capacity of 5,000 cubic feet per minute, and driven by a Pelton wheel, gives the reduction of pressure required to produce the necessary draught through the furnace, condensers, chambers and pipes."*

Queensland†.

The cinnabar country lies to the west of Kilkivan, between the heads of Wide Bay Creek and Kilkivan.

Several lodes are mentioned. One about 6 miles from the heads of Wide Bay Creek, and due west of the Black Snake Gold-mine, is described as of "brownish quartz"; and the central portion a conglomerate of broken-up particles of quartz cemented by deposition of silica from percolating waters, the pebbles being coated with small crystals of quartz. The country consists of micaceous and chloritic schists. The cinnabar occurs disseminated in the quartz, giving it a pinkish colour.

The Wolf Lode—about 1 foot thick—is composed chiefly of calcite, in which cinnabar occurs both in bunches and disseminated, the country being conglomerate, sandstone, and shales.

About 6 miles north-west of the Wolf Lode, the caps of several unprospected cinnabar lodes are reported.

About 1½ mile east of Messenger's, on King Bombi Creek, in altered sandstone and greywacke, is another lode, described as a gangue of calcite in the middle of a breccia of quartz and calcite, cinnabar and colours of gold being visible in the calcite.

Prospecting Lode.—Situated about 1 mile east of Messenger's, in coarse altered sandstone. Lode consists of a hard brown jasperoid quartz, stained with carbonates of copper. Cinnabar disseminated through the quartz.

Queensland Lode.—The Queensland claim of 80 acres—reported to contain three or four distinct lodes—of which the Queensland lode is the largest and richest, varying up to 7 feet wide in places, and averaging 4 to 5 per cent. of mercury from the dressed ore.

Mr. Rands states that 70 tons of ore yielded 6,000 lb. of mercury, with the roughest appliances for retorting and condensing the mercury. The lowest grade of lodestone yielded 1½ per cent., and the highest 23 per cent., whilst a small parcel of drift cinnabar yielded 60 per cent., the average yield being 3·8 per cent. from the lodestone.

Additional notes on these deposits, by the same authority, appear in the Annual Report of the Department of Mines Queensland for 1886, pp. 70, 71.

The *Queensland Lode*, at 42 feet, is described as consisting of a small rich vein of cinnabar in quartz on the eastern side of foot-wall, then 8 inches of quartz and calcite with cinnabar, and another mass of veinstuff in hanging wall; lode divided by a horse of mullock. Country, altered conglomerate or agglomerate "probably of volcanic origin, as it is full of angular particles."

* Papers and Reports, Mines and Minerals, New Zealand, for 1910, p. 20, c. 3.

† Report on the Geology and Mineral Resources of the Districts of Kilkivan and Black Snake. W. H. Rands, Assistant Government Geologist, 1886.

Wolf Lode.—Level driven 170 feet on lode, consisting of "sandstone and shale underlying a volcanic ash much decomposed, and containing large angular pebbles." Lode strikes north-east, averages 1 foot in thickness. Matrix contains more calcite than the Queensland lode.

"A cross-cut lower down the gully cuts several lodes or veins. At 19 feet, one of 1 foot in thickness of calcite; at 55 feet, a lode of 1 foot 2 inches wide showing good ore; at 119 feet is a vein of calcite which appears to be dipping towards some leaders at 145 feet, which contain cinnabar; and at 200 feet the Wolf Lode is cut 4 feet 2 inches wide, and contains a very good percentage of cinnabar.

"So far as the work has at present gone the prospects for the future of these mines are very encouraging."

In 1891,* Mr. Rands reported on a discovery of alluvial cinnabar on Messrs. Mactaggarts' section No. 2,447, at Kilkivan.

"A number of lodes carrying rich cinnabar have been worked on a ridge which runs through the selection in the form of a crescent. These lodes carry patches of a very high grade cinnabar, running in shoots, and are situated in a coarse-grained granite; surrounding the granite is a much altered porphyritic rock.

"The alluvial cinnabar occurs in a flat heading down from perhaps the richest of these holes—the Commotion Lode. The wash-dirt consists of a granite drift, with large pebbles of the altered porphyritic rock, and contains small water-worn pebbles of cinnabar throughout it, with occasional pieces of a large size, sometimes over 1 lb. in weight. It averages about 4 feet in thickness, and has been met with in three shafts over a distance of 9 chains.

"The reefs in this selection, from the beginning of the year up to the end of October, have yielded 1·5 tons of quicksilver from 28 tons of ore. The total yield of quicksilver from the district is 4·1 tons."

Mr. L. C. Ball† records the occurrence of cinnabar at Little River in "altered (seritised?) andesite. . . . Bluish chalcedonic quartz veins are comparatively abundant, and the andesite has in places been changed into light and dark quartzite. Elsewhere within the altered area the andesite is cellular and ferruginous, and contains minute specks of cinnabar." The best ore is stated to contain 5 or 6 per cent. of mercury, but the copper content presents difficulties in treatment. Analyses by the Government Analyst of the ferruginous andesite referred to above gave mercury ·3 and ·14 per cent. associated with ·3 and ·2 per cent. of copper.

Victoria.

Native mercury and cinnabar occur at Silver Creek, a western tributary of the Jamieson River. The site was briefly reported on by Mr. R. A. F. Murray, F.G.S., late Government Geologist of Victoria, in the following terms:—

> "The formation consists of dark Silurian slaty rocks, and the mercury occurs in bands of these, extending over a width of about 12 feet, principally in or near small strings of quartz. Globules of mercury are obtainable by breaking up and washing the slate, and can be seen in the cavities of the quartz. I was also able to detect small

* Ann. Rept. Geol. Survey Queensland for 1891, p. 17.
† Geol. Survey, Queensland, 1910, Publication 222, pp. 24-26.

patches of cinnabar or sulphide of mercury in the quartz. The quantity of the metal is, however, altogether too small to be payable; and there is no evidence justifying the hope that it will become more plentiful at greater depth, though sinking a short distance to settle the question would be advisable. So far the discovery can only be said to be of scientific interest."*

The Jamieson Quicksilver Company was formed to work this deposit, and in the *Australian Mining Standard* of the 10th August, 1899, it was announced that "a first sale of quicksilver, the product of an Australian mine, was made on August 1st, when the Jamieson (V.) Quicksilver Company disposed of a quantity retorted from ore from their mine to the local United Gleeson and Sailor Bill's Company."

New Guinea.

Cinnabar has been found in small quantities in four widely-separated parts of the Territory; on the Mambare River, in the vicinity of Mt. Scratchley, at Merani, in Cloudy Bay, on Normanby Island; and on the Brown River.†

South Australia.

In "The Mineral Industry,"‡ it is reported that large quantities of mercury were asserted to have been discovered in South Australia by a German prospector twenty years ago, and that operations were to be begun on behalf of a Victorian syndicate.

In the *Australian Mining Standard* of 29th June, 1911, it is announced that boring operations were to be continued by the Willugna Quicksilver Mining Company.

In 1885 leases were taken out for mercury in the Hundred of Myponga, 7 miles east of Willunga. The Inspector of Mines was informed that it had been found in tunnels driven into a hill. He took samples, but discovered no trace.§

In June, 1891, the district was visited by H. Y. L. Brown, Government Geologist, who inspected several localities where discoveries of mercury had been reported, and came to the conclusion that the bedrock of the tunnels and the alluvial drift at a shaft 15 feet deep both contained mercury in small quantity.‖

The Myponga or Willunga mercury occurrence was subsequently examined by Dr. H. Basedow, Assistant Government Geologist, in 1910.¶ The following notes are extracted from his report:—

"The country consists of clay slate, graphitic slate, phyllite, mica schist, and quartzite, striking north, slightly east. These beds are overlain by comparatively recent detrital deposits, with much white quartz and nodular ironstone. The country is auriferous, and several abandoned gold-mines exist in the vicinity, but no well-defined lode or body of ore occurs in the beds traversed by the tunnels in which the mercury was seen. The globules vary in size from that of fairly coarse shot to an

* Report on the country between Wood's Point and Jamieson. Dept. Mines Vic. for 1898, p. 3.
† Handbook of the Territory of Papua, 1909, p. 66. ‡ XIX, 1910, p. 595. § Record of the Mines of South Australia, 3rd ed., 1899, p. 184. ‖ *Ibid.*, p. 355. ¶ Review, Mining Operations, S. Austr., No. 13, 1911, p. 32.

excessively fine state of division, and occur either grouped or isolated. The mercury was seen on the surface only, although rock was repeatedly broken away in the hope of finding visible metal on the freshly-exposed face. It has been asserted, however, that when the fresh surface is left exposed to the atmosphere for some time the mercury 'sweats out' of the rock and collects in the form of minute beads. This may be the case of rocks *in situ*, but did not happen with the broken specimens brought to Adelaide It seems remarkable that the mercury in thus coming to the surface should not select the passages of least resistance, and appear along the lines of cleavage and schistosity of the rock, rather than having to work its way in a direction at right-angles to the layers of the lamellæ of argillaceous and secondary minerals. The mercury was found on all faces alike; in fact, in the majority of cases on the flat surfaces of cleavage or schistosity, some freshly-broken stone which did not show any trace of metal on the surface was 'dollied' and 'panned off,' when the residue in the dish showed a dull-looking streak of mercury in an excessively fine state of division, which did not readily coalesce to the familiar shining and mobile globule. This class of stone, when left exposed to the sun's rays, is said to give up all its mercury in very short time. Repeated searching for cinnabar, or other rarer combinations of mercury, was fruitless. Native mercury does certainly appear to exist in small quantity in the formation referred to, but no scientific explanation of the abundant appearance of the metal on the exposed surface can at present be given."

W. H. Mathews, Chief Inspector of Mines, further examined the locality during the first half of 1911.* The principal prospecting had been confined to two tunnels and a shaft.

"*Saupe's Tunnel.*—It has reached a distance of 120 feet from the approach. The character of the material driven through is chiefly sandstone and slate with, in places, small seams and veins of decomposed clay material. The latter, on being carefully examined, discloses small quantities of mercury in globular form. At various points short drives have been driven on the course of the vein, but in each instance the soft mercury-bearing material has gradually disappeared, showing that the veins are not continuous, but simply local splashes that have taken place from the decomposition of the rocks."

Long Tunnel.—This has been advanced a total distance of about 250 feet. The character of the material driven through is of a similar class to Saupe's tunnel, disclosing what appear to be small cavities of decomposed matter in which mercury in fine particles can be seen in each instance. Where the decomposed matter has been driven on, it has given place to close-grained slate or sandstone of no value.

"*Shaft.*—The shaft, which is in close proximity to the entrance of Saupe's tunnel, is at present 50 feet from surface; at that depth water-level has been reached. The shaft bottom discloses apparently strong silicious lode matter containing a considerable quantity of pyrites, but not of any particular value.

"From my examination of this property, on this and previous visits in the locality, there is no doubt that small quantities of mercury are disseminated over a large area; but up to the present not a sufficient quantity has been discovered to be of commercial value."

* Review Mining Operations S. Austr., No. 14, 1911, p. 27.

Quicksilver Production of the World.*

Metric Tons.

Year.	Austria.	Hungary.	Italy.	Mexico.	Russia.	Spain.	United States.	Total.
1896	564	1	186	218	491	1,524	1,036	4,020
1897	532	1	192	294	616	1,728	965	4,328
1898	491	7	173	353	362	1,691	1,058	4,135
1899	536	27	205	324	360	1,357	993	3,802
1900	510	32	260	124	304	1,095	983	3,308
1901	525	33	278	128	368	754	1,031	3,117
1902	511	45	259	191	416	1,425	1,208	4,055
1903	523	44	314	188	362	968	1,288	3,687
1904	526	45	257	†190	332	1,130	1,192	3,782
1905	519	36	370	†190	318	853	1,045	3,331
1906	526	50	418	†200	210	1,568	963	3,935
1907	527	40	434	†200	130	1,212	712	3,255
1908	594	78	684	†200	49	1,068	685	3,358
1909	637	80	771	†200	.....	1,393	713	3,894
1910	.....	.....	.....	.....	.....	.....	.....	.....

The quicksilver production of the United States for 1910 and 1911 was 22,418 and 21,500 flasks respectively.—Mining and Eng. Jl., Jan. 6, 1912.

From a very interesting and instructive compilation by J. B. Randall, of New Almaden, California,‡ the following particulars of production and price of quicksilver for thirty-nine years—from 1850 to 1888—are taken, as the period covers the most prosperous period of the quicksilver industry :—

California.

Mine.	Flasks.	Mine.	Flasks.
New Almaden	890,859	Sunderland	2,777
New Idria	128,909	Cloverdale	2,661
Redington	98,436	Abbott	2,272
Sulphur Bank	81,192	Manhattan	1,415§
Guadalupe	55,910	Buckeye	873
Great Western	58,832	Mount Jackson	597
Napa Consolidated ...	55,814	Bacon	300
Pape Valley	18,097	Bella Union	271
Great Eastern	13,161	American	250
Bradford	5,391	Porter	200
St. John	8,598	Wall-street	139
Altoona	7,527	Rattlesnake	65
Oceanic	7,391	Kentuck	54
Oakland	6,831	Various Mines	63,051
Californian	5,653		

Austria.

Idria Mine ... ... 347,586 flasks of 76·07 lb. avoir.

Spain.

Almaden Mine ... ... 1,291,636 ,, ,, ,,

The highest and lowest prices per flask during this period were, for California quicksilver in San Francisco, $118·55 in 1874 and 1875, and $25·25 in 1879.

The highest and lowest prices in London were £26 in 1874, and £5 5s. in 1883.

* The Mineral Industry, 1910, xix, p. 594. † Not reported.
‡ T. Egleston, Metallurgy of Silver, Gold, and Mercury in the United States, 1890, ii, fronting p. 901.
§ Estimated 3,594 flasks included with product of other mines previous to 1876.

The total production of quicksilver in California from 1850 to 1908 amounted to 2,052,069 flasks, computed at 76½ lb. net, up to June 1st, 1904, and since at 75 lb. net (United States Geol. Survey Mineral Resources, 1908, I, p. 684) equal to about 70,062 long tons.

The output of the great Almaden Mine in Spain was computed by G. F. Becker in 1888 as nearly 4,000,000 flasks,* equal in Spanish pounds to 135,714 tons.

Cost of Production of Quicksilver.

The following figures from the Mineral Industry, 1909, vols. xviii and xix, give the cost of production of quicksilver at the principal American mines, and that of the Idria Mine, Austria :—

Year.	Mine.	Value of Quicksilver per Flask.	Cost of Production per Flask.	Profit by Difference.
		$	$	$
1907† ...	New Idria, California	37·10	25·40	11·70
,, ‡ ...	Napa Consolidated	37·05	34·38	2·67
,, ‡ ...	Monte Amiata (Italy)	37·54	31·52	6·02
1909 ‖ ...	New Idria, California	39 85	27·53	12·32
,, ...	Napa Consolidated	38·75	34·69	4·06
,, ...	Monte Amiata (Italy)	.....	33·00	.....
,, ¶ ...	Texas, Terlingua District	....	25·00	.....

* Geology of the Quicksilver Deposits of the Pacific Slope, 1888, p. 5.
† Estimated (J.E.C.) from figures in Mineral Industry, xviii, p. 620. ‡ *Ibid.*, xvii, p. 744.
§ *Ibid.*, xvii, p. 748. ‖ *Ibid.*, xviii, p. 617. ¶ *Ibid.*, xviii, p. 619.

APPENDIX.

This edition of Mineral Resources No. 7 was prepared for publication at the end of 1911, but owing to the time that has since elapsed, a short review of subsequent local developments is necessary to bring it up to date.

During 1912 the Pulganbar Quicksilver and Copper Mining Company, Limited, concentrated its principal efforts on installation of a modern reduction plant, the small experimental retort first erected not having fulfilled expectations.

The following description of the new plant is based on notes kindly supplied by the Secretary, Mr. T. F. Flintoff, dated 18th February, 1913 :—

The reducing plant consists of a cast-iron rotary furnace, 24 feet in length, with automatic feed and discharge. The fumes are conducted into a series of six brick condensers, through which water pipes are run for cooling purposes. From the condensers four iron pipes, 18 inches diameter and 20 feet long, cooled by sprinklers, convey the fumes to two other water-cooled condensers ; from these, similar pipes conduct the fumes to two further condensers, from whence a brick flue, 3 feet in diameter, leads the waste gases to a 50-foot chimney stack. The condenser walls are 3 feet and 2 feet thick, on concrete foundations. The length of the plant from front of furnace to chimney stack is, approximately, 350 feet. The water for cooling, &c., is pumped from the adjoining creek to an elevation of 120 feet. Further pumping power is contemplated, as well as additional machinery for breaking ores to uniform grade.

Mining development was confined to further driving on the principal lodes. About 2,000 tons of ore estimated to be at grass, containing some mercurial fahlore.

The Yulgilbar cinnabar deposits, formerly held by the Great Australian Quicksilver Mining Company, were secured in 1912 by a syndicate under the name of W. Sullivan and party. Efforts were, however, confined to experimenting in the treatment of the ore. About 20 tons are reported to have been cruseed in a five-head stamper battery, and concentrated over a Wilfley table, evidently with unsatisfactory results, as the battery was subsequently sold. Another parcel was treated by mineral oil separation at Chillagoe, North Queensland, but with unknown results.

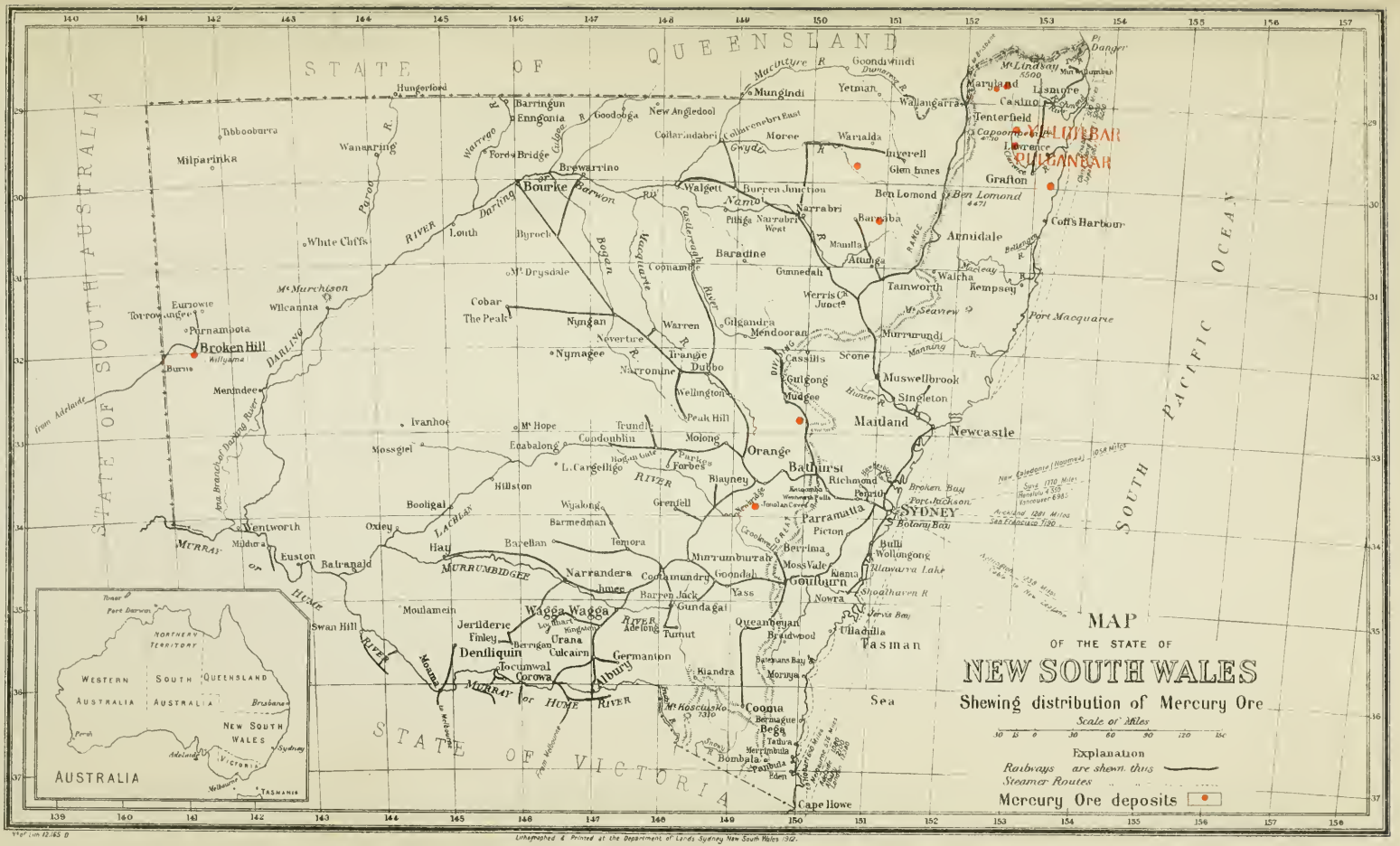
The quicksilver production of the world for 1911* in metric tons was as follows:—

Year.	Austria.	Hungary.	Italy.	Mexico.	Russia.	Spain.	United States.	Total.
1911 ...	603	90	894	(e) 250	(e) 20	1,114	763	3,734

* Mineral Industry, 1911, vol. xx, p. 654.

Sydney: William Applegate Gullick, Government Printer.—1913.

† 12182 D


STATE OF QUEENSLAND
STATE OF SOUTH AUSTRALIA
STATE OF VICTORIA
SOUTH PACIFIC OCEAN
Tasman Sea
MAP
OF THE STATE OF
NEW SOUTH WALES
Shewing distribution of Mercury Ore
Scale of Miles
Explanation
Railways are shewn thus
Steamer Routes
Mercury Ore deposits
YULGILBAR
DULGANBAR
Broken Hill
Bourke
Wentworth
Hungerford
Milparinka
Tibboobura
Wanaaring
White Cliffs
Louth
Byrock
Cobar
The Peaks
Nyngan
Nymagee
Narromine
Dubbo
Wellington
Warren
Coonamble
Baradine
Gilgandra
Mendooroon
Coonabarabran
Coonamble
Walgett
Burren Junction
Narrabri
Pilliga
Narrabri West
Moree
Collarenebri
Collarendabri
Goondiwindi
Mungindi
Yetman
Wallangarra
Maryland
Casino
Lismore
Tenterfield
Lawrence
Grafton
Ben Lomond
Ben Lomond 4471
Glen Innes
Inverell
Warialda
Barraba
Manilla
Attunga
Tamworth
Walcha
Kempsey
Armidale
Coff's Harbour
Port Macquarie
Murrurundi
Scone
Cassilis
Gulgong
Mudgee
Muswellbrook
Singleton
Maitland
Newcastle
Dungog
Gresford
Paterson
Raymond Terrace
Port Stephens
Port Jackson
SYDNEY
Botany Bay
Broken Bay
Parramatta
Richmond
Windsor
Penrith
Blacktown
Liverpool
Campbelltown
Picton
Berrima
Bowral
Bulli
Wollongong
Kiama
Gerringong
Gerroa
Shoalhaven R.
Nowra
Jervis Bay
Ulladulla
Batemans Bay
Moruya
Bodalla
Narooma
Cooma
Bega
Bermagui
Tathra
Merimbula
Pambula
Eden
Cape Howe
Mt Kosciusko 7310
Orange
Bathurst
Blayney
Carcoar
Forbes
Parkes
Peak Hill
Molong
Condobolin
Euabalong
Mossgiel
Ivanhoe
Mt Hope
Trundle
Hillston
Booligal
Oxley
Wyalong
Grenfell
Barmedman
Temora
Hay
Balranald
Euston
Mildura
Darlington Point
Jugiong
Gundagai
Tumut
Adelong
Batlow
Tumbarumba
Wagga Wagga
Narrandera
Junee
Coolamundra
Goondah
Barren Jack
Yass
Moss Vale
Goulburn
Queanbeyan
Braidwood
Kiandra
Albury
Corowa
Tocumwal
Culcairn
Germanton
Denilliquin
Jerilderie
Finley
Berrigan
Urana
Moulamein
Swan Hill
Mourquhat
Deniliquin
Wakool
Murrumbidgee
Lachlan
Murray
Hume
Darling
Barwon
Warrego
Paroo
Bogan
Macquarie
Castlereagh
Namoi
Gwydir
Macintyre
Dumaresq
Clarence
Orara
Bellinger
Nambucca
Manning
Hunter
Williams
Karuah
Myall
Wallis Lake
Lake Macquarie
Hawkesbury
Nepean
Warragamba
Cox's
Wollondilly
Shoalhaven
Kangaroo
Goulburn
Yass
Murrumbidgee
Tumut
Adelong
Kosciusko
Snowy
Murray
Hume
Victoria
Wimmera
Glenelg
Wannon
Mitta Mitta
Kiewa
Ovens
Goulburn
Broken
Campaspe
Loddon
Avoca
Wimmera
Mallee
Murray
Darling
Lachlan
Murrumbidgee

SKETCH MAP OF THE CUDGEGONG CINNABAR MINE

SKETCH MAP OF THE CUDGEGONG CINNABAR MINE

Parish of Wells. County of Roxburgh.

Scale 0 10 20 Chains

Alluvial
Devonian
Limestone
Quartz Porphyry

12182

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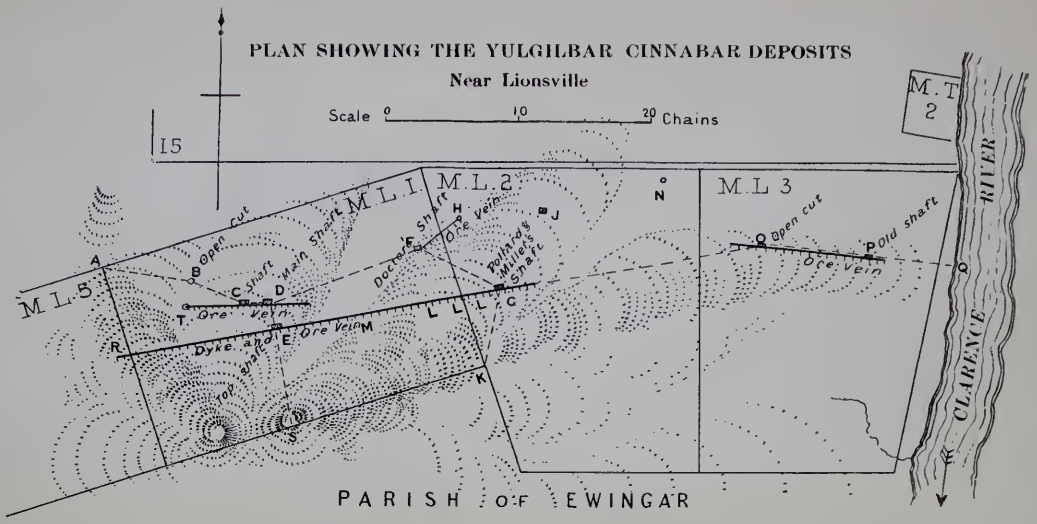
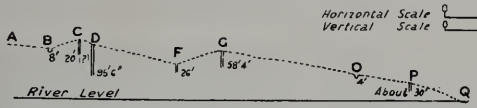
PLAN SHOWING THE YULGILBAR CINNABAR DEPOSITS

Near Lionsville

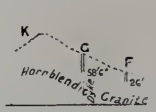


LONGITUDINAL SECTION ON LINE AQ



TRANSVERSE SECTIONS ON LINE SD

TRANSVERSE SECTIONS ON LINE KF



REFERENCE.

B — *Open Cut.* *Assay Nos.* 3366 *and* 3367

C — *Doctor's Second Shaft.* *Depth about 37 ft.*

D — *Main Shaft, "Prospectors."* *Depth, 95 ft. 6 in.* *Strike of Vein* N 76° E *Dip Southerly at* 75° *Assay Nos.* 3372 *and* 3373

H J N *Shallow openings with veinstone containing traces of cinnabar.*

F — *Doctor's Shaft, depth, 26 ft.* *Strike of vein* *Dip slight to S.E.* *Assay Nos.* 3363 *and* 3364

T — *Shallow opening showing chalcedonic quartz with stibnite and traces of cinnabar.*

R — *Augitic diorite dyke associated with cinnabar.*

E — *Shaft, depth 20 ft., fallen in.* *Cinnabar in chalcedonic calcareous veinstone and impregnating dyke rock.*

M — *Shallow opening showing usual chalcedonic veinstone and cinnabar impregnating dyke rock.* *Assay No.* 3374

L L L. *Shallow openings with chalcedonic veinstone and traces of cinnabar.*

C — *Miller and Pollard's shaft.* *Depth, 56 ft. 6 in.* *Strike of vein* N 82° 30' W. *Assay Nos.* 3369, 3370, 3371 *and* 3375

O — *Shallow opening.* *Usual veinstone.*

P — *Old shaft.* *Chalcedonic veinstone with traces of cinnabar.*

12182

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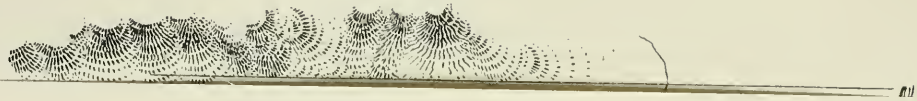
PLAN SHOWING THE WORKINGS
OF THE
PULGANBAR MINERAL PROSPECTING CO.

Parish of Pulganbar. County of Drake.

Scale 0 10 20 30 40 Chains



PLAN SHOWING THE WORKINGS OF THE PULGANBAR MINERAL PROSPECTING CO.

Parish of Pulganbar, County of Drake.

Scale 0 10 20 30 40 Chains

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